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RESTORATION OF THE POMPEIAN "HOUSE OF PANSA."

AMONG the new and interesting attractions recently added to the wonderful town of Saratoga Springs, N. Y., is the erection, under the auspices of Mr. Franklin W. Smith, of a famous Pompeian dwelling, the "House of Pansa," which is one of the finest of those uncovered from among the ruins and ashes of the ancient city of Pompeii.

The following description of this remarkable work, and of Pompeian domestic life and architecture, is given by Mr. Smith:

It is conceded by all travelers that this unique city is the most interesting and impressive sight in all Europe. It combines with the charm of antiquity the most interesting volcanic phenomenon the world has known. All are in a measure familiar with the terrible fate of Pompeii; its complete oblivion for nearly two thousand years, and a resurrection which has given this Roman city a power to interest unequaled even by the imperial capital.

Pompeii, in situation, possessed every advantage that the most exacting and refined taste could desire. Upon the verge of the sea, at the entrance of a fertile plain, on the bank of a navigable river, it united the conveniences of a city with the romantic beauty of a spot celebrated in all ages for its pre-eminent loveliness. Its environs were covered, even to the heights of Vesuvius, with charming villas. The sea shore around to Naples was ornamented with villages and gardens, so that the whole appeared as one "City of Enchantment;" while thousands of strangers who were attracted to it for health or recreation added still more to its social charms.

But a secret enemy was silently working the ruin of the fair city. We are fortunate in having an eye-witness to this unparalleled catastrophe in Pliny the younger, who said:

"Tho' my shocked soul recoils, my tongue shall tell;"

and the tale is the epitome of all terrors. Amid the revelry of gay, proud Romans, who had settled themselves in their summer homes, came a shock of earthquake like a bolt from a cloudless sky.

While yet the horror of continued upheavals was upon them, a still more horrible darkness encompassed them, until naught was visible save the awful flames of Vesuvius, which hurled upon them rocks, burning lava and red hot ashes, that either killed them outright or buried in their houses those who had no chance to escape. The air was rent with shrieks and wails of thousands fleeing as best they could through falling fire and over yawning abysses—some suffocated by sulphurous gases, as was the elder Pliny; others crushed beneath a chaos of wild horses, chariots, and crazed humanity. Many called upon the gods to help them, or prayed for death for the very fear of dying—all mingling the names of parents, children and friends, and only distinguishing each other by their voices. The real night closed in above the night the volcano had brought upon them, and when the long hours of death and destruction were over, the dawn of another day revealed a complete chaos. A smiling city was obliterated from the face of the earth, and over all its life and happiness was spread a pall of ashes white as snow, and a silence like that of the grave.

For nearly two thousand years, while empires rose and fell, Pompeii lay buried under her ashes, forgotten as though she had never been. In 1689, a humble workman, digging for a well in what was thought a wilderness, discovered signs of a dwelling far below the surface. This discovery led to the exhumation of the buried city, carried on slowly, laboriously, until about two-thirds of the area within the lines of its walls have been uncovered, bringing to light treasures of art for the admiration and instruction of the world.

The interest and importance of these discoveries to the archæologist, the historian, and the artist are too great to be dwelt upon in this slight sketch, as the "elephantine folios" pertaining to the subject attest. But the domestic life of the unfortunate Pompeians, revealed in the ruins of their homes, awakens keenest interest through that "touch of nature which makes the whole world kin." We look upon those buried homes with bated breath and irrepressible shudder, as we endeavor to realize the last agonies of their occupants in that dread hour.

Two attempts have been made in Europe to reproduce a Pompeian house—one at Aschaffenburg, in Germany, by the King of Bavaria, and another in Paris by Prince Napoleon, a cousin of the late French emperor. The former was constructed upon a moderate scale, but not furnished on account of the death of the king; the latter is merely a French chateau, decorated in Pompeian style. Of late, incongruous acquisitions of Parisian furniture, Japanese bric-a-brac and Egyptian statuary have quite overshadowed the original effect.

The so-called Pompeian house in the Crystal Palace, vacant of furniture, and with *cubicula* six feet wide, is unworthy even of the name.

When the idea of a restoration of a Pompeian house in America was conceived, difficulties appeared insurmountable. The distance from the original models; the improbability of finding artists and artisans in this country who were in any degree familiar with the style and coloring of the Pompeians; the necessity of correct details of ornament, all presented a discouraging array of obstacles. The first was overcome by three successive trips to Pompeii, and a careful study and

THE IMPLUVIUM; THE ATRIUM: VIEW THROUGH THE TABLINUM AND PERISTYLIUM.

RESTORATION OF THE POMPEIAN "HOUSE OF PANSA," AT SARATOGA SPRINGS.

measurement of all the best models, under the direction and valuable assistance of Signor Domenico Monaco, Curator of the "National Museum of Pompeian Relics" at Naples, and of Professor Luigi Fischetti, Professor of Architecture in the University of Naples, and author of "Pompeii, Past and Present."

The second difficulty was surmounted by sending from Paris to Pompeii two well known artists, Messieurs Pascal and Bernard, whose paintings have been exhibited at the French "Salon" for ten years. At Pompeii they have caught the spirit of the mural decorations of the buried city and transferred them to the new world in genuine design and color.

The third problem found solution in the resources of the great museum at Naples (where all details of architecture and ornament have been protected as soon as exhumed), as well as from casts in the British Museum, the Louvre and the School of Fine Arts in Paris.

From the numerous private houses now excavated in Pompeii, the "House of Pansa" was selected as a model, from being the most extensive, and most perfect in plan, and consequently the best known. In proportion and arrangement, this reproduction is nearly identical.

We give herewith a floor plan of the House of Pansa, as restored at Saratoga, and also an interior view looking through some of the principal apartments.

THE PLAN OF THE POMPEIAN HOUSE.

The arrangement of the houses of Pompeii was generally upon the plan of all Roman houses of the period, and conformed closely to the prescribed proportions of Vitruvius, the architect whose authoritative work has come down to us. It therefore lends an additional interest to the Pompeian house that in it we see the usual Roman habitations in the time of Christ. The homes of the citizens differed only in size and grandeur, according to the wealth of the owner; the ornaments, wall decorations, etc., varied by individual taste. To understand clearly the construction of a Pompeian house, it should be remembered that it was divided into two parts—one for family use, the other for the public. This remarkable feature sprang from the "Constitution of Rome," which permitted each patrician to draw about him as large a number of plebeians as his rank or influence could attract. These clients, as they were called, had free access to the houses of their patrons, for political conference, or advice, and they were cordially welcomed, as their votes and influence were of importance. Early in the day they assembled under his roof, awaiting his presence to ask favors or seek his aid. It was, therefore, indispensable that family privacy should be secured by special construction.

Thus the *Atrium* and *Alæ* were quite freely appropriated by the dependents or retainers. The private rooms, called the *Penetralia*, consisted of the *Tablinum*, in the center of the house; the *Peristylium* (court), the *Cubicula* (bed rooms), *Triclinia* (dining rooms), *Bibliotheca* (library), *Exedra* (conversation room), *Pinacotheca* (picture room), *Culina* (kitchen), *Lararium* (private altar), *Balneum* (bath room), and the *Zystus*, or small garden.

The facade is as precisely as possible a counterpart of Pompeian domestic architecture. This will be readily recognized by examination of the copious details of the ruins upon the walls of the *Gallery for Illustrations*. The doors are an accurate reproduction from casts in the museum at Pompeii, detailed drawings of which were supplied by Prof. Fischetti. These casts were made by pouring plaster into cavities left in the *scoriæ*, where the doors had left their imprint before decay. By the same process, skeletons have been re-embodied in plaster and are now exhibited at Naples, revealing the agony of death.

"The exterior of the Roman *domus*, the ornaments of the interior notwithstanding, was somewhat paltry, partly owing to its lowness, and partly to the absence of windows.

"The interior, on the contrary, was magnificent. What a magic effect must have been produced when all the doors and curtains were thrown back and the eye could reach from the *ostium* (entrance) through the three courts; . . . all grouped in the most charming perspective, and overhead the deep blue of an Italian heaven."*

We will take the rooms in order as they are numbered on our plan, and thus, without confusion, the reader may understand the use and details of each.

No. 1. *The Vestibule*—Opens outwardly upon the street, and inwardly upon the *Atrium*, or hall. The first object which greets the eye is a fierce dog in the act of springing upon the visitor. This device, in mosaic, was common to the larger houses, and indicates that it was a reminder of a dangerous dog within, quite necessary where houses stood so invitingly open. Beneath is written the warning "Cave Canem" (beware of the dog).

In the vestibule are brackets with four busts called "The Great and Good." This was a custom not only in Pompeii, but in Rome, by which Socrates, Plato, Cicero and Homer, and others, were installed as exemplars. "*Salve*" (welcome) greets the visitor from the pavement as he enters the dwelling.

No. 2, 2. The small rooms at the side of the vestibule were occupied by porters, who not unfrequently were chained slaves.

No. 3. *The Atrium* was an imposing hall, where the master of the house received all who were not admitted to the inner apartments. In the center of the roof is seen the *Compluvium* with a sacrificial cornice of festoons and skulls of bulls, toward which the roof sloped in order to throw rainwater into the *Impluvium*, a marble pool in the floor, where a fountain throws its cooling spray into the air—the bottom painted as a reflection of the sky above, and with seaweed also, as growing there. At the corners of the *Compluvium* roof are the lions' heads through which spouts carried the water into the pool, whence they passed into other cisterns to be used for household purposes. The ceiling of this *Atrium* is decorated with copies of the famous mosaics from the villa of Diomede, exhibited in the National Museum at Naples. A general view suggests a collection of orchids.

* Becker's "Gallus," or "Roman Scenes in the Times of Augustus," an exhaustive picture of Roman life—a romantic compendium of the voluminous dictionaries of Dr. William Smith.

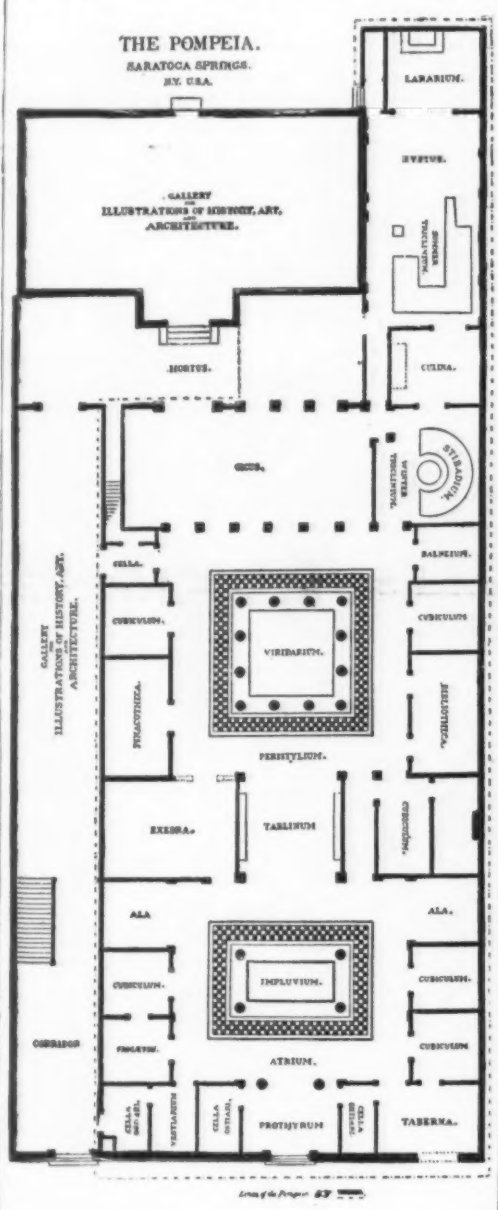
THE MUSES.

The "Muses" upon pedestals are:
Terpsichore—Dancing.
Polyhymnia—Religion.
Erato—Poetry.
Clio—History.
Euterpe—Lyric Poetry.
Calliope—Science.

Tables, chairs, couches, musical instruments, tripods, candelabra, and all other furniture have been reproduced from originals preserved in the Naples Museum or from wall pictures found in Pompeii and Herculaneum and models in the Naples Museum. The lamps also are modeled from one of the richest patterns in the great work on antiquities of Herculaneum. Every household article, from the most elaborate furniture to the most ordinary kitchen utensil, was executed with an artistic grace which reaches the acme of elegance. Even colanders were perforated with graceful designs. The taste in these details proves a study of Greek art by the artists—whereas, in our mechanical age, the skill of the artisan rather than the artist is set forth in household chattels.

No. 4. *The Vestiarium*, or cloak room, where clients were required to leave all superfluities before entering the *Atrium*.

Nos. 5, 5, 5, 5. Are an ante-room and three *Cubicula*



(bedrooms) ranged on sides of the *Atrium*—so named from their cubical form. These were invariably small and dimly lighted. Their inconvenience, to modern view, is explained only by the custom of the Romans to sleep in their apparel, and on awakening to resort to their magnificent public baths for warm and cold ablutions, and an elaborate toilet, with oils, perfumes, the friction of the strigil, and all the appurtenances of those vast and luxurious establishments. These *Cubicula* are the exact size of those in the stately house of Pansa. Specially noticeable is the bed made after the bronze original exhumed in Pompeii, with its exquisite modeling. The chair of the Muses will be recognized as familiar in ancient Greek bass-relief.

Nos. 6, 6. *Alæ* or wings, on either side of the *Tablinum*, were recesses used for rest or conversation. The ceilings are precise in size and color from the richest specimen published by Nicollini, in the most superb work yet issued upon Pompeian relics and art.

The head of Achilles is a well executed copy from the great Homeric painting found in the "House of the Tragic Poet," and founded upon scenes in the "Iliad." The illustrious Greek warrior is looking at his enemies bearing away his beloved handmaiden, Briseis; his eyes glowing with indignation, and his brow contracted with suppressed emotion. The face so full of fire, and animated with a divinity difficult to express, has given the "Head of Achilles" the reputation of the finest youthful head left in ancient color.

No. 7. *The Tablinum*, a central apartment, entered from the center of the *Atrium*. This was the private retreat of the master of the house; his *Sanctum*, where, in cabinets, were kept busts of ancestors, family archives, and genealogical tables, the latter giving the name to the room. The ceiling of this room is from a remarkably well preserved house excavated in 1865. The cabinets are supplied with *fac-similes* of ancient papyrus manuscripts and rolls of Latin, simulating accurately the books of the Pompeians. The busts are in part to illustrate kindred, and therefore are not all contemporaneous.

The "Strong Box" is a precise copy of one in the museum of Naples; as may be recognized from the drawing appended of Signor Monaco.

It will be seen from the various copies of mural paintings found in Pompeii that draperies were used, both at doors and windows, although no such textiles could, of course, have survived the destruction, even in carbonization.

From the *Atrium*, again, we turn to the right into *No.* 8, *the Fauces* (the jaws), a narrow passage which obviated passing through the *Tablinum* to inner apartments. The principal of these is—

No. 9. *The Peristylium*—a court or hall still larger than the *Atrium*, with twelve columns inclosing a space called the *Viridarium*, with Pan and Satyr among the verdure. Above was another opening admitting air and sunlight. Here were given private entertainments, when the colonnade was festooned with garlands of roses and was gay with birds of gorgeous plumage. Here beneath subdued lights moved those stately Roman men and women, in their classic robes, while music from flute and lyre stole upon the ear from slaves concealed above. It is here that Sir Bulwer Lytton depicts the meetings of the beautiful Ione with Glaucus and Arbaces in the "Last Days of Pompeii."

The ceiling of the *Peristyle* is copied from the baths of Titus. Few ceilings escaped destruction in the falling of burning rafters during the catastrophe. On the right of the *Peristyle* at the end of the *Fauces* is—

No. 10. *A Cubiculum* larger than those upon the *Atrium*. In a room situated like this was found the skeleton of a women with costly and exquisite jewelry which she had evidently collected for her escape; prevented by the overpowering ashes and sulphurous gases filling the air. Her finger bone encircled with rings found on it is still preserved in the Naples Museum. The mural decoration of this room is from the "House of Castor and Pollux."

No. 11. *The Bibliotheca*, or library, was never necessarily very large, as literature in those days was not voluminous. The rolls, or manuscripts, however, were not compact, like modern books. They were made of papyrus or parchment, and written in ink, intended to be easily washed off. There was a small ticket fastened at one end, designating the subject, and the books were frequently kept rolled up in boxes (*Scrinia*) with tickets uppermost. These books when found were at first supposed to be charred sticks of wood, but some have been successfully unrolled by the most painstaking efforts.

No. 12. The winter *Triclinium* (dining room), named from the couches surrounding the table, as Romans always reclined during meals. The size of the couch was in accordance with the rule that the number at dinner should never be less than the Graces (three) or more than the Muses (nine), excepting of course in large banquets. Grand houses had two *Triclinia*, for winter or summer use, but the ancients were much addicted to the pleasures of the table, and called frequently into requisition the *Œcus*, or large hall. At such times the floor was strewn thickly with sawdust stained in bright colors, and at one end of the hall slaves danced during the meal. A silver hoop suspended above the table held chaplets of flowers, or even of silver, for distribution among the guests. Each person reclined upon his side, with his elbow resting upon a cushion.

No. 13. *Balneum*, or bath room. As all Pompeians used the great public baths, the private ones were limited, as only for emergency. The wall of this room is from the unique decoration of the bath room in Diomede's villa—a representation of deep sea water, with fishes, and pomegranate trees on the side walls in full bearing. The marble tub is below the level of the floor, like a tank, as was the custom, and the ceiling represents an open sky, with birds, dragon flies, etc.

No. 14. *Culina* (kitchen). This was between the two *Triclinia*, and the brick stove of this room is a model of that found in the House of Pansa. When the cooks took flight they left loaves of bread, eggs, nuts and many other articles of food which are found in a fossilized state. Spits for roasting were laid across the embrasures of the stove. The bread seen is modeled from those excavated after their long burial. Chimneys are not used, charcoal not requiring them. Note the *Caladarium*, or portable kitchen, reproduced especially for the Pompeia with other bronzes in Naples. The wall painting frequently seen in the kitchen is thus described by Mazois:

"This is a religious painting found in the kitchen of the House of Pansa. It was a homage offered to the gods, *Lares*, under whose protection they placed provisions. At the center is represented a sacrifice to these divinities, recognizable under the form of two serpents. This is evidence that it is a religious and consecrated picture. Birds, a hare, fish, a boar girded for sacrifice, bread, etc., surround the principal picture, as placed under protection of the domestic gods."

The two birds chasing flies are emblems of the genii of the kitchen who drive away these pests from the food.

No. 15. Summer *Tricilinium*. Here in the summer the Pompeian families took their meals, beneath the shade of trellised grapevines as screen from sun rays. Flowers lined the walls, on which were paneled pictures making vistas—loopholes for the imagination to range beyond the narrow inclosure. The dining couch is an exact reproduction of one remaining in Pompeii; and at its precise distance from the garden walls. The panels are painted in oil from originals in Herculaneum.

The *Amphoræ* were made either to stand on the ground or to be set in other vessels, and held wine, oil, etc. The vases were used for holding water, wheat and other articles of food.

No. 16. *The Lararium*, or household temple, has above it a sacrificial picture taken from a temple in Herculaneum. The altar within has bass-reliefs of a

sacrificial procession of the gods of Olympus, and others, adjacent, are of special celebrity :

"Bacchus visiting Icarius."
"Consultation of the Oracle of Apollo."
"Apollo receiving libation from Victory."
"Bacchanalian figures."

It was here that the family propitiated their "Lares and Penates" with flowers, fruits and the blood of animals.

No. 17. *The Hortus* (garden), with walls painted in oil in the fantastic style, always followed in their outside work. The first in order represents a disciple of Bacchus after a revel; the second, a more noble Roman, recumbent in thoughtful mood; and adjoining this pair is "Orpheus charming the animals" with his music.

This ancient painting may have suggested the antithesis of Dryden :

"Orpheus could tame the savage race,
And trees, uprooted left their place,
Sequacious of the lyre.
But Saint Cecilia raised the wonder higher,
When to her organ vocal notes were given,
An angel heard and straight appeared,
Mistaking earth for heaven."*

These are the largest and best preserved pictures found upon Pompeian garden walls. The frieze above the square columns represents two spirited frescoes from the walls of Herculaneum. Barré says of these paintings that "they are the most distinguished of all those which the brush has placed upon the walls of the buried city." It represents marine horses which have broken from the yoke to revel in the waters, confronted by a terrible monster at the order of Neptune. Venus rides the waves upon a sea horse, while Cupid vaults above her with perfumes.

No. 18 *The Œcus*, or large hall, was an innovation borrowed by Pompeians from the Greeks. It was used for a banquet hall. The proportions were so regulated as to accommodate two *Triclinia*, their respective couches facing each other, with spaces for servants to pass between and around them.

No. 19. *Pinacotheca* (picture room) contains oil paintings by Pascal (above alluded to) and Zurcher. Those now on exhibition are :

1. Vesuvius before the great eruption, and Pompeii, with an ancient galley, copied from a picture in Herculaneum.
2. Vesuvius during eruption.
3. The Forum in Pompeii as exhumed, after photographs by Pascal in December last upon the spot.
4. A sacrifice in the Forum.*

No. 20. *The Exedra*, or conversation room, is supposed to supply the place of the modern drawing room, though the *Peristyle* rivaled it in attractions. Here, however, were placed some of the choicest of the adornments of a rich Pompeian house. These are illustrated by a copy of one of the most superb vases of antiquity, found on the site of the Villa Antoninus Pius, and a cast of "Europa and the Bull." The ceiling, as also that of the *Œcus*, is from the baths of Titus.

No. 21. *The Solarium* (sun terrace). Generally the houses consisted of but one story, but in some were extra sleeping rooms over a part of the structure, as is shown by remaining staircases. The *Solarium* was thus left on the roof of the front part of the building, and was the most delightful portion of the house. Shaded by vines from the street, and ornamented with growing flowers, it was the resort in warm evenings for air, and in cooler weather for sun baths. Caryatides support the trellises, and vases alternate with them, holding vines which grow in trained festoons around the roof garden.

The precedents for this *Solarium* may be observed in the "Restoration of the Roman Forum" by Cockerell in the gallery.

Wall paintings were the most beautiful and instructive relics of Pompeii. They reveal details of domestic life, of mythology and art, which could never have otherwise been preserved. These frescoes were painted upon the plaster while still moist, and thus forming a part of the wall itself, became as durable.

Landscape painting was not much emulated with the ancients. They used it merely for coarse or grotesque decoration, with little knowledge of perspective or study after nature. It was principally upon garden walls, or other outside work.

In criticism of their interior paintings, we quote an extract from a lecture delivered by Mr. Poynter R.A., at South Kensington Museum, London, and published by Macmillan in 1882.

Mr. Poynter says :

"The fragments of decorative painting (from Pompeii), arranged on the walls of the Naples Museum, display an art of design and a skill of execution which fully justify the most extravagant estimate which is recorded of Greek artists. In certain qualities of execution they are unrivaled by the best work of any of the great schools of the sixteenth or seventeenth centuries. Freedom of hand and certainty of touch are the first requisites of decorative painting, in no matter what style, but they are combined here with a rich quality of *impasto* laid on with a full brush, but with extreme delicacy, in graduations which, though as clear as mosaic in their precision, are as full and round in modeling as though done by Velasquez. . . . None but Greek artists have ever produced them, and in our hurried world they are not likely to be produced again. Nothing is more remarkable in these Pompeian paintings, even when by an inferior hand, than the impression they convey of a fresh and healthy life. The creations all live—the gestures are spontaneous and natural. There is no straining after emotion."

In addition to the splendid restoration of the House of Pansa, Mr. Smith has created an annex containing a gallery for illustrations of history, art and architecture. This annex is a vastly interesting place. It contains more than 300 rich engravings, illustrative of Roman art and architecture, including the great works of Rossini on Pompeii, Rome and its suburbs.

Ancient vases, tripods, candelabra, etc., by Piranesi, as also his "Romanorum Magnificentia," plates of the richest Roman architectural remains.

Mercante's elaborate work on the decorations of the Baths of Titus, from which Raphael drew the general designs for the Loggia of the Vatican. This is supplemented and greatly surpassed by the full series of the Loggia, engraved under the patronage of Popes Clement XIII and XIV, 1774–1776, and covering about 200 superficial feet of steel plates in exquisite workmanship, a magnificent work, encyclopedic in detail.

A very complete collection of notable works on Pompeii will be found on exhibition in the gallery. These comprise the "Antichita di Ercolano," nine volumes folio, the works of Mozois, Barré, Cook and Donaldson, Zahn, Overbeck, Bréton, Lagrèze, Gell, Steeger, Preshun, Roux, and, latest and richest, the splendid work of Nicolini. From these authorities have been taken plates, as models for decoration of the Pompeia. That their careful production may be observed, engravings from the walls of Pompeii and the museum of Naples are placed upon the respective walls which are their imitation.

Other illustrations of the period, especially interesting to the student and the archæologist, are the *coins of the period;* the "Imperatorium Romanorum Numismata," 1697; fine copies of Bartoli's "Roman Law," 1478; the Natural History of Pliny the second (who perished at Pompeii), 1525; Vitruvius, Ferrerio, Vauthier and Lacour, and Duchoul.*

The grandest restorations of the Forum yet made, by Cockerell, 1839, and Canina, 1845.

A variety of precious reproductions of Pompeian bronzes and terra cottas from Naples have been received and placed in the gallery.

There are models of bread as found calcined; of measures, perfume boxes, *tessera* (theater tickets); the sistrum, flute and other musical instruments; censers

PINACOTHECA AND PERISTYLIUM.

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* Ode on St. Cecelia's day. For this appropriate quotation the proprietor is indebted to a venerated clergyman and scholar of Boston, author of historical articles in the *Encyclopædia Britannica* on the history of New England, etc. His constant interest in the details of Pompeia was a gratifying encouragement in its construction.

* A copy of Prof. Fischetti's restoration in "Pompeii, Past and Present."

* As will be naturally concluded, these rare books are not intended for public use or handling.

for sacrificial perfumes; braziers; pastry moulds (like the modern); hinges; keys; various and beautiful models of Roman lamps; rich door handles with ornamentation, now called *renaissance;* mirrors; strigils, with which the perspiration was scraped off after the hot bath; gargoyles; rich platters and fruit dishes; bells; ointment boxes; compasses; an ax; weights; bass-reliefs of jewel cases, etc., etc. Mark the interesting bronze lamp of a human foot, with a taper between the toes; a design probably brought from the East, where the device was for prevention of bites of adders in the dark, and thus suggesting the origin of the Scriptural comparison, "Thy word is a lamp to my feet and a light to my path."

Notice the tear bottles, which, containing the tears of mourners, were placed in or near the cinerary urns, holding ashes of the dead. Three models of such urns are in the *Lararium*.

There is a slave's collar with this inscription in Latin: "I am a slave; arrest me; I am running away." This collar was no doubt welded to the neck of some wretch who had endeavored to escape from the barbarity of his master.

The colors of the exterior were revised by Professor Fischetti. His rendering of a drawing of the Facade, as also a beautiful tablet of Pompeian colors, prepared by him with his choice of pigments, may be seen framed in the gallery. It is doubtful whether moderns can possibly supply colors of the durability of the original Pompeian tints, or equal to some of them in richness and intensity. This is specially true of the blue and purple of the ancients. The Tyrian purple is probably unknown to modern art; and it has been recently announced that a French chemist has discovered the Pompeian blue.

Illustrations of Roman masonry are to be placed in the garden of the Pompeia.

. . .

In concluding this sketch of the most elaborate reproduction of a Roman house of the first century of the Christian era, as yet attempted, it may not be presuming to suggest that therein is a field for instruction far beyond novelty and entertainment. Students of history may here find dry descriptions illuminated by color and object. With an entirety of the surroundings in Roman domestic life, painted by the eye upon the retina of the brain, the lives of Plutarch and other classics will take more vivid interest.

A profoundly philosophical and interesting work* has this title:

"POMPEII—THE CATACOMBS—THE ALHAMBRA."

"*A Study by the Aid of These Monuments upon Pagan Life at Its Decline; Christian Life at Its Aurora; and Mahometan Life at Its Apogee.*

It opens upon this broad generalization by this inquiry:

"To-day, above all, when history has so well comprehended the assistance it can draw from an intimate alliance with archæology, is there a scientific pilgrimage more agreeable and more useful than that to Pompeii?"

The bare walls and broken columns of Pompeii reveal only the boundaries and divisions of its homes. Their exhumation has gathered in Naples their paraphernalia in immense multiplication; but in no practical juxtaposition; only in the show-case monotony of a museum.

May it not be an opportune and expedient substitute therefor, that professors of history in colleges and academies shall have readings of Roman archæology, with their classes in the Pompeia?

Lovers of romance may also therein re-awaken sympathetic visions with Bulwer of the "Last Days of Pompeii."

The floating or ideal figures in the *Alæ* and *Peristyle* are copied from the finest in Pompeii and Herculaneum—consisting of Bacchantes, Genii and Dancing Girls. "In the villa of Cicero, at Pompeii, discovered in 1749, there are twelve dancing girls, floating in a dark ground; fleet," says Winkleman, "as thought, and as lovely as if they had been drawn by the hand of the Graces. Many others are conspicuous for the graceful flow of the dress and harmonious coloring. The light and grouping is in many instances worthy of commendation."

. . .

Becker says: "In the time of Vitruvius it was considered good taste to possess a Pinacotheca (picture gallery). Several paintings on the walls of Pompeii are provided with frames, like borders."

. . .

Foors were never boarded. They were laid with bricks, slab-work, marble, tile, coarse and fine mosaic. Another kind of pavement was of plaster, with beaten or broken tile. In a house in Pompeii 2,000 colored slips of marble were found on one square foot.

There were not doors to all the rooms. Hence at Pompeii there are often no trace of hinges. The place of a door was supplied by hangings; the iron poles and rings of which are to be seen in Pompeii.

. . .

In Pompeii chimneys are only to be found in baths and bake houses.

. . .

"The production of the loom appears to have fallen in ancient times very little, if at all, below the beauty and variety of the damasks, shawls and tapestry of the present age; and to have vied with the works of the most celebrated painters representing mythological subjects. Fine specimens of tapestry, some with gold thread, were spread upon couches and chairs. Weaving and embroidery of *pallia* with pictures and flowers of gold was the elegant employment of females of highest distinction."—(*Smith's Dictionary of Roman Antiquities.*)

. . .

The walls and pillars of Pompeii that remain are mostly of brick, covered with cement. Those of marble perished; or were removed for other construction. Rich fragments of it remain.

. . .

Not only did the Romans gracefully salute the incoming guests with SALVE (welcome); but over the door some suspended a bird that had been taught to give this salutation.

In the pavement upon the street will be seen in mosaic HAVE; a precise replica from the House of the Tragic Poet. It is from *Aveo* or *Haveo*, another salutation of good wishes.

In the Bibliotheca are *fac-similes* of ancient rolls in papyrus, remarkably simulated in Paris, from the collection in the Louvre. As the languages Latin, Greek, and Hieroglyphic were those of the people in Pompeii, a cosmopolitan city, the scrolls must closely resemble the books of the Pompeian age.

There may be seen the latest plans of Pompeii, showing the existing lines of excavations, and indicating the houses of Pansa, the Tragic Poet, etc.

A curious and painstaking work is that by Raphael Garrucci of the inspirations, caricatures, political bonmots, etc., graven on the walls of Pompeii in *fac-simile:* "Very many inscriptions will be noticed on the walls of houses, painted usually in red letters. Most of these are election placards, asking the inhabitants to vote for so-and-so as Ædile."

"For instance:

MARCELLIUM, ÆDILE, M. LIGNARI, ET PLOSTARI, ROGANT.

"The carpenters and carvers wish Marcellius to be Ædile. These advertisements generally ended with the letters O. V. F. (Ovo vos facitus.) 'Please vote for him.'"

In the Bibliotheca are also thirty-three busts of Roman and Greek rulers, philosophers, etc.

. . .

Especially to be remarked for richness of design and ornament are bronzes of finest workmanship in the *Atrium* and *Tablinum*. The superb tripod found in *Herculaneum* has for many years been sold in Paris in miniature as a model of highest art. The same is true of the candelabrum and lamps "upon a rectangular pillar crowned with a capricious capital" placed upon the marble table in the *Atrium*. The figure of Victory and the small bronzes of drunken Silenus are interesting contrasts of subjects.

Colossal busts of Jupiter and Melpomene are upon buttresses of the Roman arch of the art gallery. That of Diomed in the Œcus is of powerful Roman cast in heroic size.

. . .

The following extracts are from the late work of E. Nelville Rolfe, B.A., of Norfolk, England, now a resident of Naples. The title is well vindicated by its contents, "Pompeii. Popular and Practical. An easy book on a difficult subject."

It excels previous publications in satisfaction of curiosity, as in the fragments appended.*

"With regard to glass in Pompeii, we observe that it was in common use. Many windows were glazed. It is in the nature of things that fine glass should have been broken, and that the coarser specimens should have survived to us."

. . .

"We have ocular demonstration that the Pompeians frequently colored their statues. Plato tells us (B. C. 347) that in his day the ancients colored their statues."

"Let us glance for a moment at the religion of the period, of which Gibbon says justly that it was considered 'by the people as equally true, by the philosophers as equally false and by the magistrates as equally useful.' The worship was utterly degraded, but their temples were kept up with great splendor, and their ritual was carried out with extreme minuteness."

"And if the religion of the country was in decadence, could it be said that the sacred Fount of Justice was any purer? We are afraid we must reply that justice no longer presided over the law. Apart from the atrocities perpetrated by the emperors, the cruelty and venality of the judges was notorious, and bribery of the worst kind was universally practiced."

"The theater, and especially the comic stage, was as degraded as it could be. The upper classes were extremely wealthy. We can hardly credit the sums expended by them on a single banquet."

"Yet with all their luxurious extravagance they were a deeply wretched race. Their magnificence could not give them happiness, and Horace wrote of them, 'dark Care brooded over their brazen pleasure boats and sat behind their caparisoned horsemen.'"

INSTANCES OF THE EFFECTS OF MUSICAL SOUNDS ON ANIMALS.

By ROBERT E. C. STEARNS.

CATS AND MUSIC.

MR. GEORGE GUION, of Ventnor, Isle of Wight, referring to a cat owned by his friend, a Captain Noble, says:

"If any one in her presence commences whistling a plaintive air, Brownie will presently go to him, climb into his lap, and raising herself on her hinder legs will put her mouth close to that of the whistler. Captain Noble's view of the motive is that the cat imagines the performer to be in pain, and thus endeavors to express her sympathy. One day when sitting round the table after dinner, we each for experiment attracted the animal in turn, who on the above supposition must have thought we were suffering from an epidemic, as each of us in succession exhibited the same symptoms. It is necessary that the air whistled should be of a plaintive character, as I found by commencing a lively measure, which I had to change. In my boyhood we had a cat which had a habit very similar. If I laid myself down on the sofa and made a moaning noise, the cat would jump up and hover about me, as if anxious to find out what was the matter."

Another party writes: "Some time since I had an ordinary tortoise shell cat, which had a peculiar fondness for the tune known as 'Rode's Air.' One day I chanced to whistle it, when, without any previous training, she jumped on my shoulder, and showed unmistakable signs of pleasure by rubbing her head against mine, and trying to get as near my mouth as possible. I have tried many other tunes, but with no avail."

Captain Noble, of Forest Lodge, Maresfield, England, whose cat "Brownie" is referred to by Mr. Guion, in response to the incident above given, says: "By the bye, I don't know whether 'Rode's Air' is a lively or plaintive tune, but only one of the latter kind affected my poor old 'Brownie.' I used as a rule to whistle the 'Last Rose of Summer' when I wished her to perform. I never could satisfy myself as to her motive in putting her mouth to mine. The most feasible conjecture that I was able to make seemed to be that she imagined me to be in pain, and in some way tried either to soothe me or to stop my whistling."

F. C. R., of Gwasted, in commenting on one of the instances above related, says: "We too have a cat which is very sensible of the whistling of tunes, and which will, even when with her young kittens, show great uneasiness immediately after the whistling commences, and rise and leave them to follow the person about, ending by trying to seek for the unaccountable sounds in the very mouth of the performer. Still, unlike the cat of 'Musicus,' she seems to experience more uneasiness than pleasure."

Then follows E. J. T., who says: "I can give another instance from personal knowledge. A few years ago my brother had a favorite cat, which, when he whistled a tune, would follow him round the room, and climbing up on him would touch his mouth with her paw, and rub her head against his face, all the time purring with pleasure. I may add that this musical taste is *not* hereditary, for a grandchild of this cat, now in our possession, shows the greatest antipathy to music; a few notes on the piano or concertina are enough to rouse her from her slumbers on the hearth rug, and drive her to the door, mewing loudly to be let out."

Another illustration is furnished by Mr. Oborn, relating to the power of music on English cats. He writes:

"I have a cat that has apparently great fondness for music. Whenever any of the family or a stranger commences playing on the piano, and if the tune is at all lively, she fondles and purrs and evinces the greatest pleasure imaginable, and sometimes becomes so excited that she will jump on to the keys and rub herself against the hands of the person playing."

A lady friend of mine residing in California has observed similar actions on the part of a cat, when the piano is playing in its presence. Whether a Thomas or Tabby cat I did not ask.

Another friend, a lady residing in Washington, D. C., at one time owned a cat that acted in a very peculiar manner upon hearing the music of a piano. When the strain was rather soft and low, the cat appeared to be pleased with it, would climb up into the lady's lap, reach up her head and rub it against the lady's shoulder or chin, but when in the course of the time a passage was reached that was in a high key, with considerable emphasis, pussy became intensely excited, and would put her head against the lady's cheek with a good deal of force; or jump down and run to the piano, and climb up on the person playing, and get up on the instrument in such a fiercely aggressive way that the performer, through fear of being scratched or bitten, would stop playing.

Referring to the effect of whistling upon a cat, as observed by E. J. T., Mr. George O. Howell says: "A relative of mine has a cat, a noble animal, rejoicing under the refined name of Thomas. This creature dislikes to hear any one whistle. But one morning when he was fast asleep I whistled loudly. It acted like magic. Thomas started up in an instant, looked very bewildered, and decamped from the room at full speed."

From dogs and cats, the canine and feline, let us turn to the porcine.

PIGS AND MUSIC.

"In old churches and cathedrals we sometimes find a carving on the miserere of a pig playing upon a bagpipe and the little pigs dancing around. This seems to indicate a popular notion (at least in times gone by) that pigs have no ear or taste for music; such a notion, however, seems to be not quite correct, for I once saw four or five great bony pigs standing at a garden gate, listening with the most evident pleasure to the sweet sounds of a wandering German band. They stood in a row, in perfect stillness, with heads bent a little on one side to catch the melody: and from time to time gave utterance to their delight in a gentle grunt of satisfaction. The melody that charmed their breasts was one which rose and fell in gentle and continual waves of sound; not very attractive perhaps to educated ears, but certainly riveting the attention of these untaught creatures, whose desires are commonly supposed to be confined to the quantity and quality of their food, rather than to the enjoyment of the purer delights of sweet sounds."

In proceeding with the domestic animals it will be seen that the bovine group are entitled to a share of attention.

MUSICAL COWS.

"That pigs are not the only animals who take a delight in musical sounds, may be proved by the following incident of which I was a witness on more than one occasion. Opposite to our house was a large field in which some twelve or thirteen cows were put during the summer months. One day a German band commenced to play on the road which divided the house from the field. The cows were quietly grazing at the other end of the field, but no sooner did they hear the music, than they at once advanced toward it, and stood with their heads over the wall attentively listening. This might have passed unnoticed; but upon the musicians going away, the animals followed them as well as they could on the other side of the wall, and when they could get no further stood lowing piteously, etc. . . . So excited did the cows become, that some of them ran round and round the field to try and get out, but finding no outlet returned to the same corner where they had lost sight of the band, and it was some time before they seemed satisfied that the sweet sounds were really gone. It seems a strange coincidence that both the pigs and cows were charmed by music produced by a German band."

OXEN AND MUSIC.

"I have often noticed the power music has over oxen. The other day we had a brass band playing in our garden. In a field adjoining were four Scotch oxen; when the band struck up, they were at the far end of

* Lagrese, Paris, 1873.

* Mr. Smith states that a concise abridgment of some of the most interesting material from this and other works will be issued from the Pompeia as soon as practicable.

this, a nine-acre field, quite out of sight, the field being very uneven. They set off full trot to the garden wall, put their necks over, and remained so till the tune was finished, when they went back to graze; but as soon as it struck up again they put their heads over again. This went on till the band left, after which they ate little all day, and were continually lowing."

Before leaving the bovines, it may be worth noticing that the most definite statement, the most direct and practical testimony we have as to the effect of music upon members of this group, may be found in that famous book known as "Mother Goose's Melodies." Therein it is stated:

"There was a piper had a cow
And had no hay to give her;
He took a pipe and played a tune,
'Consider, cow! Consider!'

"The cow considered very well,
And gave the piper a penny,
And bade him play that other tune,
'Corn ricks are bonny!'

It will be observed that she was a *hard money* cow, while the piper offered only notes!

"There are many anecdotes which show that the ox, or cow, has a musical ear. The carts in Corunna, in Spain, make so loud and disagreeable a creaking sound with their wheels, for the want of oil, that the governor once issued an order to have them greased; but the carters petitioned that this might not be done, as the oxen liked the sound, and would not draw so well without their accustomed music."

"Prof. Bell assures us that he has often, when a boy, tried the effect of the flute on cows, and has always observed that it produced great apparent enjoyment. Instances have been known of the fiercest bulls being calmed into gentleness by music."

It will be seen that a very liberal definition must be conceded to the terms music and musical sounds, when the creaking of a cart wheel is referred to as "accustomed music."* The instance here quoted may be more properly regarded as illustrating the relation of certain sounds to the ordinary routine, and said sounds having been continued for a long time, until they became a permanent factor in the experience of these animals, the discontinuance caused, perhaps, a feeling of strangeness and discontent.

SHEEP AND MUSIC.

The following pleasing anecdote of the power of music is given by the celebrated Haydn. "In my early youth," says he, "I went with some other young people equally devoid of care, one morning during the extreme heat of summer, to seek for coolness and fresh air on one of the lofty mountains which surround the Lago Maggiore, in Lombardy. Having reached the middle of the ascent by daybreak, we stopped to contemplate the Barromean Isles, which were displayed under our feet, in the middle of the lake, when we were surrounded by a large flock of sheep which were leaving their fold to go to the pasture.

"One of our party, who was no bad performer on the flute, and who always carried the instrument with him, took it out of his pocket. 'I am going,' said he, 'to turn Corydon; let us see whether Virgil's sheep will recognize their pastor.' He began to play. The sheep and goats, which were following one another toward the mountain, with their heads hanging down, raised them at the first sound of the flute, and all with a general and hasty movement turned to the side from whence the agreeable noise proceeded. They gradually flocked round the musician, and listened with motionless attention. He ceased playing, and the sheep did not stir.

"The shepherd with his staff now obliged them to move on; but no sooner did the fluter begin again to play than his innocent auditors again returned to him. The shepherd, out of patience, pelted them with clods of earth, but not one of them would move. The fluter played with additional skill; the shepherd fell into a passion, whistled, scolded, and pelted the poor creatures with stones. Such as were hit by them began to march, but the others refused to stir. At last the shepherd was forced to entreat our Orpheus to stop his magic sounds; the sheep then moved off, but continued to stop at a distance as often as our friend resumed the agreeable instrument.

"The tune he played was nothing more than a favorite air, at the time performing at the opera in Milan. As music was our continual employment, we were delighted with our adventure; we reasoned upon it the whole day, and concluded that physical pleasure is the basis of all interest in music."

Having given much time to the domesticated quadrupeds, the domesticated bipeds, our friends who wear feathers, must be permitted to give their testimony.

I am again indebted to Prof. Davidson for many interesting anecdotes, all the more so as the instances recited have the authority of his personal knowledge, or that of others known to him as truthful and intelligent.

BIRDS AND MUSIC.

First relating to pigeons. "It must have been about 1841 when I had gotten rid of about fifteen pairs of pigeons of different varieties; but I retained a fine white 'hen pigeon' because we all felt a kind of attachment toward her—the younger brothers and sisters and my mother. I was going through the task of learning the flute from my father's teaching. I had only a one-keyed flute, but of very sweet tone. Our white pigeon had always made herself at home about the back part of the house, frequently leaving the large pigeon house and coming into the kitchen; but after the sale of all the other pigeons she was continually among our feet, and making close friends with one and all. In the course of my fluting we noticed that this white pigeon became very much excited over one particular tune, but as to the others she seemed wholly unconcerned. So to please the younger portion of the family, as well as my mother, I frequently cleared a space for the pigeon to perform in and commenced to play. She would begin to circle round and round in the most excited manner, in a space say six feet or more in diameter, crouching low, spreading out her wings and cooing in the most intense tones. It was very interesting to us all, and the louder I played, the more excited became the bird. She never exhibited any feeling for any other tune. Very frequently my mother would ask a neighbor or two in to see the performance, and to still further test the pigeon's idiosyncrasy I would begin to play while she was outside, when she would instantly leave her corn and come in for the music. Two of my sisters write me that the tune was 'Rule Britannia,' and that the pigeon was then ten years old. Subsequently I purchased other pigeons and mated her, after which she evidently considered music too frivolous for such aged maternity."—*American Naturalist.*

* But then Will Carleton's verses are sometimes called poetry.

DECURRENT-LEAVED MUTISIA.

Mutisia decurrens.

THE figure that accompanies this note represents one of the most interesting of the many exotic plants that adorn the gardens of Britain. We do not aver that it is the most beautiful, for, in respect of beauty, it is distinct, attractive, and much to be admired; but no claim can be made for it that in beauty it is either unique or exceptional. It is particularly interesting for one reason, that there are few plants so difficult to keep; and for another reason, that to grow it and keep it is easy enough for those who understand it.

Mutisia decurrens is one of forty species of Mutisia, a genus of composites the species of which are more or less remarkable in growth; and many of them not less so for the size and beauty of their flowers. Some of these have pinnated leaves; others have entire leaves that terminate in tendrils, as in the example before us. M. latifolia, figured by Sweet in his "British Flower Garden," vol. iii., second series, t. 288, is characterized by a curious leafage, and winged stems, the flowers being smaller than those of the plant before us, and of a soft rosy pink color. M. grandiflora is, perhaps, the most to be desired after M. decurrens, but appears not to be in cultivation in Europe at the present time.

DECURRENT-LEAVED MUTISIA.

Mutisia decurrens (Flowers brilliant orange color).

The Decurrent Mutisia was introduced by Messrs. Veitch & Son, through their collector, Mr. Pearce, from the Chilian Andes, in the year 1860 or 1861, and was figured in B. M., t. 5273. It is a hardy climber, with peculiar decurrent leaves, of a glaucous green color, and flowers of a brilliant orange color. It is described in B. M. as "climbing to the height of a few feet." On the wall of the museum next the pond, in Kew Gardens, a plant may now be seen that is about ten feet high, and has been flowering freely for two or three months past, presenting an attractive appearance, both by reason of the gay color of its flower heads and the distinct form and glaucous tone of its leaves.

If we sum up the merits of this plant by likening it to a climbing gazania, that is perfectly hardy in the climate of London, we shall be giving a fair idea of its claims to admiration. But we have remarked above on the difficulty of keeping it, the consequence solely of the liking of slugs and snails for the young growth as it rises from the ground; for, if these enemies have access to it, they will effectually prevent its ever rising to the dignity of a flowering plant. At Kew the difficulty is met by the simple precaution of spreading broken coke over a space of about two square feet where the plant is situated. Over or beneath this the marauders can make no progress, and thus it is secured.

In comparing our figure with the one above cited, and with another in the "Florist and Pomologist," 1862, page 81, we find that in both the flowers are represented of large size and with much broader ray florets. It is not for us to say that they are exaggerated, and, indeed, as they are from the pencil of Mr. W. H. Fitch, we take them to be faithful in every particular. Our figure represents the flowers as they appeared in the Kew specimen when at its best in the month of July last, and the figure is an admirable example of the conscientious work of Miss Ada Brooke. —*The Gardeners' Magazine.*

A DEVICE FOR RAPID ADDITION AND EXTRACTION OF THE CUBE ROOT.

By Professor CLARENCE M. BOUTELLE, Principal of the Public Schools of Decorah, Iowa.

1. *When the Numbers to be Added consist of One Figure Each, and the Sum is less than* 100.

Use two counters, called the adding counter and the "carrying" counter respectively.

Place both counters on the 0 in the left hand column to begin. Move the adding counter down to the number named, then horizontally to 0. Repeat for each number added. Whenever the adding counter passes below the heavy horizontal line, move it horizontally to the left to 10, then vertically to 0, and move the carrying counter down 1. When the addition is completed, move the adding counter horizontally into the left hand vertical column; read the tens of the sum from the "carrying" counter, and the units from the adding counter.

A little practice will enable one to move the counter only up and down, letting the eyes move to the right and left to determine the horizontal line in which to stop.

2. *When the Sum is between* 100 *and* 1,000.

Use three counters placed side by side on the 0 of the left hand column in beginning. These counters, used for the hundreds, tens and units respectively, must have distinctive shapes or colors; one may be white, one blue, and one red, for instance.

The adding counter for tens is also the "carrying" counter for units, and the adding counter for hundreds is the "carrying" counter for tens. Move the respective counters in succession, beginning with hundreds and ending with units, for each number as it is read; use the approximate "carrying" counters, as in the first case, whenever a counter passes below the heavy horizontal line.

3. *When the Numbers have any Values Whatever.*

Use as many addition blanks, arranged side by side, as there will be periods of three figures each in the sum and use three counters in each blank. Add the hundreds, tens and units of each period in succession, beginning with the highest, "carrying" in each period as before, and remembering that the lowest counter in any period is the "carrying" counter for the highest order in the period below.

A little practice will enable one to add, with absolute accuracy and almost no mental effort, any set of numbers assigned, and *almost as rapidly as they can be distinctly read aloud.*

In adding sums of money, the lowest period may be given to cents and mills.

The author proposes further on to show how other arithmetical processes can be made easier and more rapid by use of the addition blanks. In brief, he will show that "addition blank" is only one of the many names appropriate to this useful device.

ADDITION BLANK.

0									
1	0								
2	1	0							
3	2	1	0						
4	3	2	1	0					
5	4	3	2	1	0				
6	5	4	3	2	1	0			
7	6	5	4	3	2	1	0		
8	7	6	5	4	3	2	1	0	
9	8	7	6	5	4	3	2	1	0
10	9	8	7	6	5	4	3	2	1
	10	9	8	7	6	5	4	3	2
		10	9	8	7	6	5	4	3
			10	9	8	7	6	5	4
				10	9	8	7	6	5
					10	9	8	7	6
						10	9	8	7
							10	9	8
								10	9

EXTRACTION OF THE CUBE ROOT.

The following method of extracting cube root, *when the conditions are such that the root is known to be a whole number less than* 1,000, is much shorter than the one given in a recent issue of this paper. By its use, the root of any perfect cube of three periods can be determined mentally, and, unless the unit figure is 5, *determined almost instantly.*

1. Table 1 must be committed to memory. No one ever attempted to extract many cube roots without learning it. Its use enables us to write the first and last figures of the root of a perfect cube at once.

TABLE NO. 1.

$1^3 = 1$	$4^3 = 64$	$7^3 = 343$
$2^3 = 8$	$5^3 = 125$	$8^3 = 512$
$3^3 = 27$	$6^3 = 216$	$9^3 = 729$

2. Table No. 2 need not be learned, for the simple reason that any one well versed in multiplication and division is already in possession of the facts it illustrates. The numbers in the left hand vertical column represent the figures found at the right hand in divisors. The numbers in the upper horizontal line represent the figures found at the right hand in divi-

TABLE NO. 2.

	0	1	2	3	4	5	6	7	8	9
1	0	1	2	3	4	5	6	7	8	9
2	0 5		1 6		3 7		3 8		4 9	
3	0	7	4	1	8	5	2	9	6	3
4	0 5		3 8		1 6		4 9		2 7	
5	0 2 4 6 8					1 3 5 7 9				
6	0 5		2 7		4 9		1 6		3 8	
7	0	3	6	9	2	5	8	1	4	7
8	0 5		4 9		3 8		2 7		1 6	
9	0	9	8	7	6	5	4	3	2	1

dends. The other numbers represent the figures found at the right hand in quotients. Thus, for illustration, the exact division of any number by a divisor whose unit figure is 1 gives a quotient having its unit figure the same as that in the dividend; the exact division of any number ending in 5, by a divisor ending in 5, gives a quotient ending in 1, 3, 5, 7, or 9, etc., etc.

3. In the well known formula $(h+t+n)^3 = h^3 + 3h^2t + 3ht^2 + t^3 + 3(h+t)^2 n + 3(h+t)n^2 + n^3$, the denomination of the right hand figure of $3(h+t)n^2$ is tens, and, n^3 having been subtracted from a perfect cube, the right hand figure of the remainder and the right hand figure of $3h^2$ determine the right hand figure in $(h+t)$, that is, they determine t.

Examples:

1. Find the cube root of 918,330,048.

Table No. 1 gives 9 for the hundreds and 2 for the units.

$2^3 = 4$. $3 \times 4 = 12$. $048 - 8 = 040$.
$04 \div 2 = 2$ or 7.

A momentary comparison of 918 with 729 assures us that the larger number, 7, is the right one.

2. Find the cube root of 741,217,625.

9 hundreds; 5 units.
$5^3 = 25$. $25 \times 3 = 75$.
$625 - 125 = 500$.
$0 \div 5 = 0, 2, 4, 6,$ or 8.

(This is the only really difficult case.)

Comparison of 741 with 729 convinces us that either 0 or 2 is correct, and the trial of 2 settles the question speedily in favor of 0.

3. Find the cube root of 188,132,517.

5 hundreds; 3 units.
$7^3 = 49$. $9 \times 3 = 7$.
$517 - 27 = 90$.
$9 \div 7 = 7$.

(This is one of the cases in which there is no doubt; 1, 3, 7, and 9 give only one set of quotients.)

4. Find the cube root of 7,645,373.

1 hundred; 7 units.
$7^3 = 9$. $9 \times 3 = 7$.
$373 - 343 = 030$.
$3 \div 7 = 9$.

One cannot but be astonished at the rapidity of this work. A speed of probably ten or twelve examples per minute can be reached by a bright boy drilled for a short time in this method.

CLARENCE M. BOUTELLE.

THE MANAGEMENT OF SILK WORMS IN CHINA—A TRANSLATION FROM THE CHINESE OF TSOU TSU-T'ANG.*

Translated from the Chinese by ROBERT KLIENE.

I.—THE MULBERRY TREE.

CULTIVATING the mulberry is a source of support, and farming and weaving are the origin of wealth to the people. From this it is seen that those who till the ground should not put aside the silk worm and mulberry. But, to succeed, the soil must be suitable, the lands broad, and proper care must be exercised in the rearing.

Since the twenty-first year of Tao Kwang I held an appointment at Mei Chu, Chien-p'ing. I noticed that the products of the place were few and scanty; that the people had scarcely food and covering; and what they depended on to feed the living and bury the dead with was what they expected from the harvest in autumn. What little remained from that was spent in receiving the gods in processions and theatrical performances, and in burning incense. Even when the crops were good, they could not avoid borrowing; when they met with unfavorable seasons, they bemoaned the miseries of hunger and cold.

I felt sorry for them, and, not having abilities, I could not better their state; but, having been born and brought up in the province of Chiang-nan, I knew about the mulberry and silk worm. Chien-p'ing is in the Yang-chow prefecture; the soil is the same, there being a great deal of spare land connecting with the provinces of Chiang-nan and Che-chiang; so I thought the silk worm could be easily introduced and the manner of rearing soon learned.

Then why should I delay introducing the silk worm and mulberry tree, thus increasing the native products and bettering the state of the people? I consulted my superior, and he told me to speak to the gentry. They said it would be well. Thereupon rules were made, blocks cut for printing the directions, and means adopted to prevent the stealing of the plants. Men were sent to Hu-chow and other places to select and purchase mulberry plants. These were distributed among the people to plant in vacant ground to rear silk worms and reel silk. This proved to be of some benefit, and a yearly profit was derived therefrom. The people became well-to-do and comfortable.

Hereafter colleges and free schools will be instituted, proficient teachers and professors will be engaged to instruct the people, and the people will be able to attain all literary honors, and the place will be renowned for its learning. Will this not be happiness indeed?

Your advancement is my wish.

Dated tenth moon of the twenty-sixth year of Tao Kuang. TSOU TSU-T'ANG.

A native of Wu-hsien, residing in the "Hall of Diligence."

RULES COMPILED BY THE GENTRY OF CHIEN-P'ING FOR THE CULTIVATION OF THE SILK WORM MULBERRY.

The soil of Chien-p'ing is barren and the people poor; of late the grain has been cheap, to the injury of the farmers, who, if met by an unproductive year, become totally ruined. Tsow K'ang-chai, assistant magistrate of Mei Chu, who prays day and night for the welfare of the people and for good harvests, and who discussed with us the introduction of the silk worm and the mulberry tree, has petitioned his superior to post placards over the country and depute some one to undertake and supervise the cultivation of mulberry trees, etc., to subscribe from the official appropriation for the purpose of printing and distributing books on the culture of the silk worm and the mulberry tree, and to personally visit and encourage the villagers. He has exerted himself to the utmost for the benefit of us villagers in introducing what is advantageous and removing the evil, and by scheming for the future and wishing for the general culture of the silk worm and mulberry tree, so that we need no more moan on account of inundation or drought, and that the poor may become rich and the barren land fertile.

We pray our good villagers will take the good advice given them. Now we have compiled a set of rules and adopted means to prevent thefts.

All this has originated from the desire for the cultivation of the mulberry tree, and we trust that the people will agree with us that this will be feasible.

Any persons having good plans are requested to add them to the rules.

Do not sit and allow this great opportunity for profit to slip by. We hope that all of us will embrace this scheme with a will. This is most important.

(1) Let all who wish to purchase mulberry plants in each division of the town send to Hu-chow and other places in the beginning of winter and procure trees of 6 or 7 feet. Let it be understood that what is wanted is the silk worm mulberry, and not the wild mulberry. Smaller farmers may buy for themselves, or ask the greater farmers to buy for them, so as to save the expenses of carriage. But let each suit himself.

(2) Each family planting mulberry trees must do so in their own ground. No one must forcibly plant in official ground, or ground that is not owned by any one in particular, so as to bring about disagreements and lawsuits.

(3) Land owners having land and hillsides and letting the same as tenants must plant the trees themselves, to be taken care of by the tenants. The profit derived from the sale of leaves should be equally divided between the two parties. Should the owner not desire to plant the trees, and the tenant does, he must come to an understanding with the land owner that, when paying the rent, he (the land owner) must take into consideration the value of the trees and make a just deduction from the rent, and it must also be agreed that the tenant shall not dig up the trees so as to destroy the ground.

(4) The mortgagee must plant the trees on mortgaged lands. At the time of redeeming, the mortgageor will arrange and refund to the mortgagee the outlay for the trees. The mortgagee must not put preposterous prices on them.

(5) Mulberry trees must not be planted on graves, lest they should injure the ancestral coffins, and on public roads and narrow strips of land they must not be planted, lest they become objectionable to traffic.

(6) There are high and low beds in the fields. Each one planting mulberry trees must plant on the high beds in his own fields, and not below them.

Do not cultivate the tall mulberry, lest it should take away the rain and dew from your neighbor's land. But, if the soil all round be owned by the planter, he may, of course, suit himself.

(7) It is hard to find out who steals plants, cuts down trees, or steals leaves at night. The planters should take turns to watch, so as to avoid thefts.

(8) The person on whose field a theft is committed must arrest the trespasser himself, and, if the articles stolen be found on him, he must be sent to the authorities for punishment. Any one giving information or appearing as witness will be rewarded accordingly. But the person giving false evidence for the purpose of avenging some personal ill feeling not only will receive no compensation, but will be forced to make necessary amends. Persons allowing cattle to graze on mulberry plantations will be duly punished. Wood cutters must not, by mistake, cut down mulberry trees. Children must not be allowed to break off branches. Any offending will be sent to the authorities for due punishment. Their fathers and elder brothers will also be arrested. Parents must, above all, instruct their children to avoid trouble.

(9) Unprincipled villains will, for some personal grievance, privately transplant their own trees to the fields of their neighbors and falsely accuse them of stealing, or put another's trees there for the purpose of getting them into trouble. Such people are very wicked, and Heaven will surely punish them. But if such acts can be proved against them, they should be sent to the authorities, who will punish them severely.

(10) Let mulberry trees be planted in all broad lands and each family learn to rear silk worms. One tael of silk-worm eggs will produce 100 taels of worms, which will consume, from the first to the final sleeps, 2 piculs of leaves. These will afford labor for thirty-odd days. Then they will spin, and the silk will bring in 4,000 to 5,000 cash. Nothing takes so little capital and brings a greater profit than silk. In Hu-chow they rear silk worms three times a year. For directions consult the books on the subject printed and distributed by the Assistant Magistrate Tsou.

(11) Mulberry trees, as well as grain, depend on the richness of the soil. But people must not take rich soil from lands in which they have no share.

We advise each family to keep many pigs, that the mulberry plantations may be fertilized with their excrement, and the soil will then become rich.

(12) The leaves and twigs that have been cut off can be used as fuel. The leaves that fall in winter can be used as medicine and as food for sheep. The sheep's excrement will answer for fertilizing purposes, so will that of the silk-worms you keep. The pupæ of the silk-worms can be eaten, and the moths lay eggs, so here lies the highway to wealth.

Nothing can be more profitable.

HINTS ON MULBERRY CULTIVATION.

(1) The spot chosen for mulberry cultivation should be high and level in preference to low and swampy land. Too much water is injurious to the roots, and it is impossible for the mulberry to thrive in wet soil. The soil must, besides, be rich.

(2) The trees must not be too closely planted, and should be 7 or 8 feet apart. Holes 1½ feet deep and 3 feet in diameter should be dug, a thick mixture of liquid manure and earth put in, then put in the plants and add earth firmly beaten down. This obviates the necessity of watering daily. Before planting the roots must be thoroughly washed and the bad and useless portions removed. What remains should be straightened out to allow the plants to grow with ease.

(3) The depth of winter is the best time for planting. The trees planted in the first and second months of the year will live, but are more liable to be troubled with insects.

(4) The plants must be stout. These will produce thick and tender leaves, and must be manured in winter and spring. The best way to do this is to dig a small hole near each tree, fill it with manure, and cover with earth. In this way the strength will go downward and force the roots deeper into the ground.

(5) No weeds must be allowed to grow at the foot of the trees, as they absorb the nourishment and will soon impoverish the soil. Stones, also, should not be allowed to interfere with the growth of the roots, and should be removed whenever other duties permit.

(6) Before the mulberry trees have become full grown, vegetables may be planted at the foot of the trees, as the constant working on the soil is beneficial to the plants, thus making the soil answer two purposes. But care must be taken that the roots are not troubled. If melons and such like things are grown, the vines must not be allowed to creep over the trees.

(7) When the mulberry tree is healthy, it is round like an umbrella. This is the result of good care. To take good care of the trees is to keep them well trimmed and pruned. Where the branches are few, more twigs should be left here, when pruning, and allowed to spread. Where the branches are all dead, they should be cut off and new shoots will come out.

When buds appear, the dry portion of the branches should be removed with pruning shears, leaving the rest. After the beginning of the second summer (that is, the second summer after the trees have budded for the first time, or the third after planting) cut away all but three or four of the healthiest twigs grown the year before. In the next year do the same and leave two or three more twigs, and so on until the fifth year, when there are already four growths. After that cut off all new twigs that may grow, keeping only those that have grown in the four previous years. Branches that are crooked or growing downward must be cut off, and those growing crosswise, or that are in the way, should also be removed.

Leaving the twigs does not mean that they should never be cut at all. They must be trimmed to about 5 or 6 inches from the branches. The word "branches" must not be misunderstood. It means those branches from which new twigs grow. For instance, the 5 or 6 inches that are left of the new twigs of one year become the branches for the next year's twigs.

(8) The trees may have branches growing from the side of the trunk near the ground. These may be converted into separate trees. When these branches have become about two feet long, loosen the earth and bring the branch or twig down to it, put some rich soil over it and keep it down with a stone, leaving only the top of the branch out and allowing it to grow upward. After a year the part under the earth will have already put forth roots. Then cut it from the mother tree and transplant.

(9) The wild mulberry, when it is as thick as a finger, may be changed into the cultivated mulberry by the usual grafting system. Silk-worms can be fed on wild mulberry leaves, but the leaves are small and thin, and the trees produce many berries. Therefore, they must be improved by grafting.

(10) When the leaves of the mulberry tree turn yellow and the branches dry up in spite of the energy of man and the richness of the soil, this result is caused by insects. There are two sorts of insects that trouble the mulberry—one kind on the outside of the bark and one inside. The kind inside varies from 1 to 2 inches in length and is hidden from sight. They ought to be destroyed at once. To do this one must search on the trunk and main branches of the tree for the nest. This is easily found, as there is always dirt, etc., about the holes. A wire should be used to draw out the insects. If this does not answer, boiled wood oil may be poured in. This will surely destroy them. The heads of the insects are turned upward from the first to the fifteenth of the moon. After the fifteenth they are reversed, and then it becomes hard to get at them. Those wishing to destroy these insects should be up early in the morning, before the fifteenth, and use the above means. As they come out before dawn to sip dew, operations should begin either before they retire or before they go too far into their nests. If this opportunity is neglected, there is no help, as the insects will go deeper and deeper into the tree, and will ultimately destroy it. The insects that grow outside are seen in the fifth and sixth moons. They resemble the silk worm in appearance, but are smaller, and are known

* Forwarded by Hon. Thos. F. Pettus, U. S. consul at Ningpo, with his report to the State Department, March 10, 1890.

at the *pai ts'an* (white silk-worms). They live exclusively on the leaves. The leaves, though they may be large and healthy, will become like sackcloth as soon as these insects trouble them, and the following spring they will be scanty. The method for destroying these is to mix in water some essence of tobacco (the latter may be obtained by boiling tobacco stalks, which can be had from all tobacco dealers) and sprinkle it over the leaves. The insects will die when they eat them. This must be done at once on detecting the presence of the insects. If delayed, they will, in a very short time, spin and make useless cocoons. From these cocoons come the moths that lay eggs for next year's worms. Then they will become difficult to destroy.

(11) The buds of the mulberry tree are known as the first crop, and the leaves that follow these, after they have been picked, are called second crop. If the first crop is not picked, the leaves of the following spring will be thin; even if they are more than the silk worms can eat, they should be picked. The leaves of the second crop need not necessarily be picked until the frost sets in; then they become fattening food for sheep. In picking leaves care must be taken not to hurt the twigs, as from these twigs leaves will grow again next spring.

(12) In picking the leaves there should be a system; those that appear older should be the first picked, allowing tender or younger ones to grow. Care must be taken that the *yu-tsui* (the center or tenderest leaves of a bud) are not hurt. If they are left alone, they will in a few days increase a thousand fold; besides, when young, they are bitter and pungent, and not liked by the silkworms. New or young silkworms need but little food, so the *ti-pan* (first or lowest, hence oldest, leaves of a bud) will be sufficient for the time, if the *ti-pan* is kept, it will not come to much. After the second sleep the worms will gradually need more food. If the *ti-pan* will serve, well and good; if not, then take the *hsia-yeh* (blind leaves, *i. e.*, those between the *ti-pan* and the *yu-tsui*). After the third sleep still more leaves are required; now ascertain if they are full grown (after the *ta-mien*—final sleep—the leaves will be perfect), and cut them off with shears, beginning with the oldest.

The *ti-pan* and *hsia-yeh*, which are picked before the third sleep, are usually known as the *hsiao yeh*, or small leaves.

Trees producing naturally 100 catties of leaves, if well cared for, will yield 20 to 30 per cent. more.

If the young leaves are picked year after year from the trees, they will soon become exhausted. Therefore, it would be wise to do so every other year; for instance, one plants one hundred trees: for the first year one should pick the young leaves of fifty, leaving the other fifty until after the final sleep, and use the large leaves, and reverse the proceeding in the following year.

(13) When the trees grow old they either dry up or become hollow. It is not possible that they will last forever. Plant others on any side near the dying ones; in two or three years cut the dead trees down and let the fresh ones grow instead, or cut away the old trees (before they are dead), leaving stumps 6 or 7 inches from the ground, and cover them with rich soil; in the following spring new shoots will come up and they will become *ti-sang* (low mulberry); this is also a good method. The leaves come out earlier on the *ti-sang* than on the others, and will be of service when small or young leaves are in demand. But being near the ground, the leaves are liable to be bespattered with mud during heavy showers, and must be thoroughly cleaned before given to the worms.

(14) The leaves of the *che* (oak) can also be given to the silk worms, but being thicker and tougher than the mulberry, they are not suitable for young worms.

When mulberry leaves are short, they may be given two or three times after the third sleep (at the *kai kow*—opening of the mouth—*i. e.*, before they have eaten anything else) and five or six times after the *ta mien*, or final sleep; by doing this a great many mulberry leaves will be saved.

They reason why the oak should be given before the mulberry is that its flavor is not so good as that of the mulberry; and if the latter is first given, the worms will refuse the oak.

(15) Mulberry plants come from Chia-hsing, Hu-chow, and neighboring places. These plants are very hardy; although they have been out of the ground three weeks or a month before being replanted, they will live, provided the roots are not dried up.

II.—SILK WORM REARING.

(1) The most important part of silk worm rearing is the preservation of the eggs. To select cocoons for the next year's worms, take the cleanest and hardest ones on the upper portion of the *t'su* (the straw bundles on which the cocoons are spun), male and female in equal numbers; those on the lower portion are less prolific. The pointed ones with small circumference are the males; the round and thick ones are the females. Take off the loose silk on the outside and string the cocoons together on a thread. In stringing take care not to pierce the cocoons so deep as to hurt the worm. Now hang them in a quiet place where they will not be shaken; if shaken, the moths will become what is known as the *ch'eh* (stupid moths). To avoid rats the cocoons must not be hung near the wall or posts.

After ten days the moths will come out; as soon as they have made their appearance, separate the males and females and put them in different places. The males have smaller abdomens than the females. When a number have come out, put them together, still keeping an equal number of each set. If there are more of one set than of the other, keep the extra ones for the moths that come later. Allow them to pair by themselves; as soon as they have paired put them aside, and separate them after eight hours. They must neither be separated too soon nor too late; if too soon, many of the next season's worms will not sleep, and if too late, there will be disease among the worms.

Place the egg cloths (cloths upon which the moths lay eggs) over bamboo trays—old or new cloths make no difference, but they must be square; now put the female moths on them. Lay rulers along the edges of the cloths to prevent the moths laying outside, and cover with something to exclude light; in half a day the cloths will be covered with eggs. Although there is no fixed hour for the moths to leave the cocoons, they usually make their appearance about daybreak. A person should be watching and remove them as soon as they come out; otherwise they will pair on the cocoons, and thus baffle the attempt of keeping them together for the proper length of time.

(2) When the cloths are covered with eggs, hang them in a large and clean room to dry, keeping them away from the wall and posts. In six or seven days they will turn black; new eggs are yellow; they afterward turn greenish, and last of all black. Turning black is the sign that the embryo is formed. Now pulverize lime and sprinkle it evenly over the eggs through a sieve; take care not to put it on too thick, but just sufficient to cover the eggs. When this has been done, fold the cloths up and loosely tie them with a tape and hang in a quiet place. In the midst of the winter take them down and salt them. If the lime is not used after the eggs have turned black, they will be hatched long before the spring comes.

(3) To salt the eggs: On the 12th day of the twelfth moon take down the egg cloths and gently dust the lime off, and sprinkle cold baked salt over them, covering the eggs; now refold the cloths and soak in cold tea; there let them remain until the 24th day of the same moon. On that day take out the cloths and spread them over bamboo trays; pour clean water over them slowly, but frequently to remove the salt; if the water is poured on too quickly, it will wash away the eggs. After a little while taste if all the salt is removed; then allow them dry; fold and put between wadded clothing in boxes. No weight must be laid on them, and no perfumes.

After the following *Ch'ing-ming* (usually at the beginning of the third moon), take the cloths out and hatch by the heat of the human body.

The eggs that are not salted are known as the *tan chung* (fresh seed). These are more liable to disease; they grow larger and consume more leaves; besides, the cocoons they spin are less hard and thick than those of the salted kind.

(4) The eggs are hatched by heat, but the heat must not be too great. When the mulberry begins to bud at *Ch'ing-ming*, take the egg-cloths down, fold them once or twice according to their size (if folded too thick the heat of the body will not penetrate them), and wrap them in paper; during the daytime place them on the chests or backs of persons not doing hard work, lest the perspiration destroys the eggs; during the night put them into the wadding of quilts, but do not lie on them. If the weather is warm, they may also be kept in the quilts during the day. In six or seven days the eggs will be hatched. If the quilts are used the wadding must be new (old wadding does not retain heat). Should the season be late, delay the hatching a few days.

(5) When nearly all the eggs are hatched, spread some papers over a wadded quilt in a room where there is no draft; but the paper must be white and smooth, somewhat larger than the egg cloths. Let two persons open out the egg cloths, allowing the side with the eggs on to face the paper already spread out, about 3 inches above it, and tap the back with a small bamboo slip; when nearly all the worms have fallen on the paper, sweep them gently together with a feather. Keep the unhatched eggs warm, and repeat the proceeding over another sheet of paper later on. Now put the worms into a tray of bamboo or willow twigs—but not on anything newly painted or varnished—and spread out evenly with chopsticks prepared for the purpose. These are made of bamboo 7 inches long, and thinner than the ordinary chopsticks; they are round and pointed at the lower end, which must be perfectly smooth. If the worms are spread unevenly over, they will not go to sleep at the same time. All this must be done between 10 o'clock in the morning and noon, as it might be chilly before that time, and the young silk-worms are very susceptible to the cold. Before putting the worms into the trays place half an inch of straw ash in the bottom to keep off the damp; spread a piece of paper over the ash, then lay the paper with the worms on in the center of it, leaving plenty of margin so as to give lots of room for the worms when they have grown.

(6) As soon as the worms are spread out, leaves must be put on; they must be cut into very narrow strips and laid over evenly. When the weather is warm, the worms must be fed four or five times a day, and more than the usual quantity to be given at the last or evening feed. But when the weather is cool, the worms will not be inclined to eat the food given them; in such cases wrap wadded quilts round the trays to keep the worms warm, then they will eat. The weight of the quilts must not fall on the worms.

In damp or chilly weather the heat from a heating pan will, of course, make the worms eat; but it makes them liable to disease, so it must be avoided.

(7) After the worms have been fed some ten times their numbers appear to have increased; at this period divide and put them into different vessels, separating them gently with the chopsticks. After they have been fed some ten times more divide them again in the same way.

(8) The refuse of leaves and excrements of the worms must not be allowed to accumulate in great quantities in the trays, or the heat and dampness of the same will bring about an effect decidedly injurious to the worms. Four or five days after the worms have been hatched the refuse and dirt will have collected in a sufficient quantity for changing trays. To do this, wait until the worms have finished all the leaves given them, and sprinkle ashes of paddy husk over the worms through a sieve, then put fresh leaves over the ashes, and the worms will crawl out from under the food. (The reason why paddy husk ash is used is because it is the most convenient, and can be obtained by burning paddy husk in an earthenware pot uncovered.) When this is done, gently remove the leaves (with the worms) and place them in another tray; do this a second time if there are still more worms in the ashes, and any that may remain after this may be thrown away or removed with the chopsticks. Ashes must also be put into the new trays (see section 5), to keep off the damp. After the second sleep it will no longer be necessary.

(9) Two or three days after changing trays some of the worms will turn a whitish color, their mouths become pointed, and will not eat; this is the first sleep. If all the worms are not sleeping, feed them as usual until nearly all sleep, then sprinkle paddy-husk ash over them in the manner already described, and put on fresh leaves; those that are not yet sleeping will crawl out from under the ashes. Remove these gently with the chopsticks and place them in a separate receptacle; after being fed a few times more they, also, will go to sleep. Try the ash process again, and the worms that do not sleep after this may be thrown away. They are known as the *ching tóu* ("green heads"), and will be found among the best worms; they will be useless to keep.

The worms that are sleeping, separate gently, sprinkle some more ashes over them, and remove into a quiet place; there let them remain until they wake. Do not put together those that went to sleep at different times, as the ones that go to sleep first will be the first to wake.

(10) Look at the worms every other day; when the color becomes yellowish and the mouths grow broader, they are waking. Do not feed them too soon, but wait until all under the ashes have awakened before putting on the leaves. When they awaken they will crawl from under the ashes. After having fed them once or twice they must be put into separate trays in the manner already described. After each sleep the mouth becomes broader and the skin thicker; both these changes take place during the sleep, and, if fed too soon after waking, they will not be able to crawl out of the skin, which may not have completely left them.

(11) By this time the worms begin to consume much more food, which necessarily produces more refuse and excrement; now change trays every other day.

(12) Four or five days after the first sleep, or when the worms have been fed some twenty-seven or twenty-eight times, their color again becomes white and their mouths pointed, and once more they refuse to eat. This is the second sleep. They must be treated in the same manner as in the first, and the same to be done in the third sleep.

(13) After the second sleep the refuse of leaves, etc., becomes still more; now change trays every day.

(14) Four or five days after the second sleep, or when the worms have been fed some twenty-seven or twenty-eight times, the color becomes whiter and the mouths plainly pointed, and the worms will not eat. This is the third sleep. Now sprinkle ashes over the worms in the manner as mentioned above, and spread some leaves over, which must be gently rolled up when the worms that are not sleeping have crawled on. It is not necessary now to use the chopsticks, so remove the worms into a separate tray with the fingers; the chopsticks are only meant for the small or young worms, but when they have grown large it is more convenient to use the fingers.

(15) The worms that have not yet gone to sleep will do so in a few hours, and should be fed until they do sleep. The greenish ones, having a greasy appearance, that will not eat, and constantly shake their heads as if in pain, will never go to sleep; even if they do, they will be of no use, so remove them at once.

(16) After the third sleep the worms eat much faster. They must be fed day and night, putting on fresh leaves as soon as they have finished one supply. During the daytime feed them six or seven times; if the weather is cool, they will eat less and more slowly, so four or five times will be sufficient. Toward evening the leaves must be put on thickly, and at midnight do the same. The reason why the supplies at evening and at midnight should be greater than during the day is that the worms cannot be fed as frequently at night. Four days' feeding at this rate will bring the great or final sleep. The time between the third and final sleeps varies from three to five days, according to the temperature and the rate at which the worms eat. If reckoned by the number of feedings, it usually amounts to over thirty.

(17) The appearances of the final sleep resemble those of the first, second, and third, but the manner of treatment differs greatly. Feed until nearly all the worms have gone to sleep, and spread whole leaves over them, without the ashes. Those that have gone to sleep will remain quiet, while those awake will crawl on the leaves to feed. As soon as a number have come up, put on fresh leaves without waiting for the others to be finished. Continue some ten times, when there will be as many layers of leaves between the sleeping and the other worms. Roll up the leaves with the non-sleeping worms on, and spread them over another tray; these, also, will soon be asleep.

Pick out the sleeping worms and put them on a flat bottomed tray, the shape and material of which will make no difference, but avoid anything that is newly painted or varnished. When the tray is full weigh it, with the worms, to ascertain the amount of leaves still wanting. Five catties of worms in their final sleep will require, above what has already been consumed, about one hundred and odd catties of leaves. After weighing put them into a basket and divide each catty into five or six lots, allowing plenty of room between the lots, and sprinkle pulverized lime over the worms through a sieve, to dry them; then cover with hay, cut into lengths of half an inch, not too thick, but just sufficient to cover the worms.

(18) In twenty-four hours the waking worms will crawl from under the lime and hay. If the weather is warm, the waking will take place in twenty-four hours, and if cold, later, sometimes even as late as two or three days. But they must be allowed to awaken on their own account; on no occasion try to hasten them with heat or by putting on leaves too soon. All worms must be awake before feeding them.

(19) After the final sleep the worms eat still faster, and must be fed more frequently; as soon as one supply of leaves is finished, put on another. If fed some ten times in one day and night, the worms will be matured in five days and nights. From the time of awakening after the final sleep until the worms become perfect they should be fed some fifty-odd times, the more frequently the better, as each mouthful eaten at this time means so much more silk; consequently people rearing silk worms are fearful lest the worms do not eat enough.

(20) After the final sleep the worms require more baskets or trays daily; for instance, what would go into ten baskets to-day, on changing to-morrow will require twelve or thirteen, and the day following sixteen or seventeen. If there should not be sufficient baskets or trays in the course of time, an inclosure on the floor can be built for receiving the worms. To make this inclosure select a light room, clean it well, and decide upon the size according to the number of worms. Take thick mud bricks of a foot square and place

them firmly three feet apart for supports, then make the sides of thick boards or smaller bricks; cut straw into pieces of an inch long, and strew the floor with it. Now spread the worms on, not too closely, nor yet too far apart; if the worms are too far apart there will be a waste of leaves, and if placed too near each other they will not become fully developed at the same time.

(21) The worms must not be placed in the inclosure too soon, as there are no means for clearing away the refuse of leaves, etc. Two or three days after awakening from the final sleep would be about the time, as shortly after that time the worms begin to spin, so the accumulation of dirt, etc., will not become so thick as to occasion any danger of dampness.

(22) There must be spare space outside the inclosure to admit of enlarging when necessary. If the worms in the inclosure are thicker at some places than at others, spread them out evenly; but should the whole be too thick, then gradually move the bricks and boards back, add more bricks for standing upon, put in more cut straw, and bring the worms on this from the parts where they are crowded. This is commonly known as *fang ts'ang* (literally, enlarging the *ts'ang*, or inclosure).

(23) If two or three days after the final sleep it is noticed that some of the worms shrink, their joints become high and drawn together, they refuse food, and constantly crawl to and fro on the leaves with a white liquid coming out at the feet, immediately remove these, and do not allow the other worms to become infected.

(24) When the silk worms are about fully developed, clean out a room with windows in and strew straw over the floor. If the floor be low and damp, erect a platform of boards a few inches high and put the straw over that. If no boards are obtainable, then dry the floor by covering it with lime before putting the straw on. Now place whisks of straw (called *shan*) upright in six or seven tiers in readiness for the worms to spin upon. If the room faces the south, from east to west is counted as one tier, or if the room faces the west, from south to north is counted as one tier. When the worms commence spinning, begin by placing them on the inner or first tier. When five or six tiers are covered have in readiness some ten tiers more, but do not wait until all the whisks are covered before preparing fresh ones. If there are two stories to the house, the upper one would be the better. When the worms first begin to climb keep them from the sun and wind, but when the nests are formed for the cocoons they must have plenty of light; therefore, rooms with many windows are preferable. Should there, however, be no spare rooms with windows, then surround them with matting until they have *shang shan* (or climbed the whisks), then remove as soon as the nest is formed.

(25) In placing the whisks do not put them too near the walls, as it is the nature of the silk worms to get as high as they can, and those on the whisks nearest the walls will climb up and make their cocoons on the ceiling.

The *shan*, or whisks, are to be made of straw. To make them tie a four-pronged rake to something with the toothed side upward; now take a handful of straw, and, holding it by the upper end, run it along through the prongs of the rake to remove all the tangling leaves, etc., which are soft and hairy. These leaves are not able to bear the weight of a silk worm, and, being hairy, need more silk to support the cocoon. Now tie the straw together with a strong string in the shape of a bamboo brush about 1½ feet long. Cut the ends even about 1 foot from the string on one side and 5 inches on the other, or as much as the breadth of a hand. It is now what is known as the *shan shou* (literally, "hill broom"). Now take hold of the whisk at the string with the left hand, and with the right hold the lower or shorter part—having one end of the string in each hand—and give the straw a twist. This motion will tighten the string and expand the ends of the whisk at the same time. Continue until it appears like two basins with the bottoms placed against each other.

(26) In placing the *shan* put them in a position that gives the greatest stability. For instance, the first *shan* in the second tier is to be placed to face the space between the first and second *shan* in the first tier, the second *shan* to face the space between the second and third *shan*, the third tier in the same relation to the second tier as the second is to the first, and so on. When a silk-worm is fully developed it becomes yellow like an old ivory chopstick, soft as cotton and transparent. When such are noticed, spread leaves over them, and the less matured ones will continue to feed, while the perfected worms will come above the leaves and shake their heads as if begging. Now is the time to remove them. Removing the matured worms is known as "picking out the old worms." Put on fresh leaves as soon as the others are finished, and take off the worms as they come up. Should there be more than could be attended to, use willow twigs for removing them. To do this place leafy willow twigs over the mulberry leaves for the old worms to crawl on. Then remove the twigs and put them into a sheet of any other cloth, and let two persons take the four corners, leaving the middle part of the sheet hanging. A third person takes the willow twigs and shakes them gently, when all the worms will drop off upon the cloth like rain. When done, immediately replace the twigs over the leaves, and go through the process as often as required.

(27) The worms thus shaken out are to be removed to the whisks on trays. Put them on the whisks systematically, covering the first tier before beginning on the second. If put on irregularly, there will be places where there are no worms. Put from sixty to seventy on each whisk.

(28) Five or six feedings after the appearance of the first perfected worms, and all the rest will be ready for spinning. They must not be put on the whisks too late, for, after the proper time, the cocoons they spin will be thin. Yet they must not be put on too soon, because they will *ting shan*, which results in two days delay on the straw whisks.

(29) It is a piece of luck to the keeper of silk-worms if the weather is clear and mild at the time his worms begin to spin, as the cocoons will be completed sooner and more easily reeled. Should the weather be wet and chilly, fires can be made to keep the worms warm, otherwise there will be a *ting shan*. The fires must be well screened, as all the surroundings are inflammable. This is the only period during the life of a silk-worm when a fire can be used without injury.

(30) A day or two after beginning to spin there may be some silk worms which lift their heads and have nowhere to hang the silk for spinning. In this case put some bamboo branches or willow twigs on top of the whisks about seven or eight inches apart; this addition is known as the *ch'ing shan*, or "green hills." Silk worms that have once reached the top will not come down again, and the consequence is that there is no alternative but to add to the whisks. This can only be done after 90 per cent. of the worms have made their nests to spin in, otherwise the worms below will also crowd upon the *ch'ing shan*.

(31) On the fifth day after beginning to spin the cocoons will be ready and may be taken off. To do this it would be well to first remove those that were first begun. Before taking the cocoons off the whisks see that there are no dead or decayed worms among them. Handle the cocoons gently, as too much pressure flattens them. If dead worms are found on the whisks, turn them upside down and shake the worms out before removing the cocoons, and do not let them come into contact with the silk. The skins of dead worms are very thin and break when touched, and, if broken on the whisks, they will spoil the cocoons.

(32) After the cocoons have been taken off spread them out on trays in a cool room, remove the loose silk hanging round them, and have them in readiness for reeling. Replace those that have been thus cleaned.

If the weather is warm, place the trays containing the cocoons over pots filled with cold water to keep them cool.

The time between *lo-chien* (removing the cocoons from the whisks) and *ch'u-o* (when the moths come out) is reckoned to be ten days, and the forming of the moths within ten days. Although the moths are formed and not yet come out, the silk is not ready for spinning. The cocoons must be cleaned after their removal from the whisks, and therefore cannot be reeled right away, but the reeling must be done within a week; and by keeping the cocoons in a cool place the forming of the moths will be delayed a day or two, thus giving a little more time to get through with the work. To avoid the moths biting through the cocoons some people place them over a fire to kill them. This may seem a natural enough thing to do, but those who do so seem not to know that, having gone through this process, the silk not only becomes difficult to reel, but also loses its fine gloss.

(33) The cocoons must be weighed after they are taken from the whisks. If the weight of the cocoons is known, the weight of the silk to be obtained is also known, and the time it takes to reel them can then be easily calculated. One hundred catties of cocoons will yield 10 catties of silk. A good hand is able to reel, by using the double cash machine, 1½ catties in a day, or the whole in seven days. If the single cash machine is used, then 1 catty of silk can be reeled in one day, or it will take ten days to reel 100 catties of cocoons.

(34) Should there be among the cocoons some that are decayed inside and wet outside, which are called *yin-chien* (negative cocoons), they should be taken out when sorting the cocoons, and should on no account be reeled together with the good ones, for, if mixed together, they will dirty the water and take away the gloss from the good silk.

The bad cocoons are to be soaked in clean water, which must be changed twice or three times a day. After having finished with the good silk pound out the decayed matter from these, wring out the water, and dry them in the sun. There is no time to do all this while reeling the other silk, and a few days' soaking will do them no harm. When the silk is thoroughly cleaned and becomes soft, reel it off by hand. The silk need not be fine, it has only to be of one thickness. This is made into *mien ch'ou*. The manner of reeling by hand can only be learned by seeing it done; it cannot be described by the pen.

(35) The cocoons which are kept for eggs are called after the moths have come out, *o-k'ou-chien*. Soak these in clean water for a day or two—there is but little dirt on these besides what there is on the outside; they should not be soaked any longer—then wring, and dry them in the sun. Their use is the same as the *yin-chien*, and they are reeled in the same manner.

(36) The stone used for reeling is round, 2 feet high, being larger above and smaller below. This shape is to allow room for the legs of the person reeling. It is 1 foot 6 inches in diameter (or 4 feet 8 inches in circumference) above and 1 foot 1 inch in diameter (or 3 feet 3 inches in circumference) below. The pan must be well plastered on and not allowed to smoke.

(37) The water used in reeling silk must be of the purest and cleanest obtainable from mountain streams. The best will be that nearest the spring itself. Never use well water, it destroys the glossy appearance of the silk.

(38) The reeling machines must be perfect, as the least departure from symmetry will prevent their working smoothly. Carpenters who have been long at Huchow, Chia-hsing, and neighboring towns would know best how to make them.

(39) There must be a furnace behind the wheel, in a direct line of that portion of the wheel to which the silk is wound. If the double cash machine is used, two furnaces will be required, and if the single, only one. The silk leaving the water must pass over the fire—say about 2 inches from it; if further, the heat will not be sufficient, and if nearer, the silk will be burned. In this manner the silk dries as soon as it is reeled, and if this is not done the silk will stick, which means more time wasted in disentangling it when required for use.

(40) The fuel used for such furnaces should neither smoke nor crack. The smoke spoils the silk, and the sparks, in cracking, burn it.

(41) To the left of the stove, or furnace, there must be a wooden tub, and brought to the level of the pan. This is for receiving the pupa, or chrysalis, of the silk worm and the cocoons that cannot be reeled. (The pupa is the first change of the silk worm, and the moth is the second.) When the reeling is completed and the machine taken to pieces, pick out the thicker of the unreelable cocoons and put them together with the *yin-chien;* keep and treat them in the same manner. Put the rest in a pan and boil in water. After having thoroughly boiled them stir them round with a brush, then the silk will be separated from the pupæ and become one sheet. On the following morning take it out and put into a rush basket, weighted down with something heavy, and after that shake out the pupæ and dry in the sun. This kind of silk is called *ssu-ta-t'ou*. After all the other silk has been reeled spread the *ssu-ta-t'ou* out evenly on trays and beat out what remains of the pupæ, etc., with flexible strips of bamboo in a little water, then thoroughly dry and reel by hand. The uses of this silk are the same as those of the *yin-chien*, and if worn on the back in winter, over the under clothing and under the wadded jacket, it will be found very warm.

(42) When the day is ended and there are still some cocoons unfinished in the pan (these are called *t'ang-t'ou-chien*), place them in a basin and mix them with the raw cocoons the following morning. Raw cocoons are those that have never been in water.

(43) The way to reel silk is hard to describe and can only be acquired by constant and close watching when it is done by others, and this can be accomplished by being present at places where reeling is done. Should you have friends or relatives in Chia-hsing, Hu-chow, and neighboring places, advise them to learn the art of reeling silk. After they have mastered it they can teach numbers of people on their return home.

(44) People rearing silk worms would do well to calculate the amount of leaves they expect from their trees. The young worms, known as the *ts'an-'hua*, should be weighed as soon as they are hatched. One mace of these, if well cared for, will weigh at the time of the final sleep 5 to 6 catties, and they will need through their whole life 130 to 140 catties of leaves; hence in selecting the *ts'an-'hua* it will be unwise to keep too many. In weighing the *ts'an-'hua* first get the exact weight of the cloth (to be used), then weigh it again with the worms on. In this manner the exact weight of the *ts'an-'hua* will be ascertained. The reason why a cloth is used on the scales in weighing the worms is to prevent the worms from being injured by the cold brass plate.

The sections following this will treat of the worms in general.

(45) There are two kinds of leaves the silk worms will not eat, viz., the "golden" and the "oily." The golden leaves are those covered with yellow spots, and oily leaves are black and appear to be covered with a coating of grease. If pressed, the latter kind will turn oily after a little time. When mulberry leaves have to be brought from a distance, one cannot help their settling in baskets and pressing upon each other; in such cases the leaves ought to be aired on the way. To do this, choose a shady spot where there is a current of air, and loosen the leaves. This must be done every 20 li. There are also two kinds of leaves which must not be given to the silk worms—the watery leaves and the leaves of trees grown in barley fields. The one kind produces bad silk and the other is decidedly injurious to the worms. This fact must be borne in mind by both the planter and by the rearer of worms.

(46) The leaves for the day's use should be picked at the dawn of day. If earlier they will still be wet with the dew, and if later they will wither more easily. The leaves for the night and next morning should be picked about sunset. Leaves gathered in the burning sun will not keep long.

(47) People rearing silk worms must study the weather. When it threatens to rain, leaves for two days should be gathered. If the quantity be small, they should be kept in jars, but should the quantity be large, then heap the leaves on bamboo mats in a place sheltered from rain and wind. If the rain should outlast the supply of leaves there will be no alternative but to proceed to pick in the rain. Spread the wet leaves between cloths (if new, white should be used, and if the cloths be old any color will answer), and in a little while the leaves will be quite dry; or mix them in cleaned, dry wheat (there is dust in the uncleaned grain), in this manner the leaves will also dry in a short time. But, should it be after the final sleep, when a large quantity of leaves is needed, gather them with the twigs and hang them in a place where neither rain nor wind can harm them; these in a very short time will be dry enough.

(48) The reason why leaves for the silk worm should be cut is that by doing so they can be more evenly spread, and a saving made. The breadth of the strips should be determined by the size of the worms they feed. For newly hatched worms the strips should be no broader than the thickness of a thread, after the first sleep one-twentieth part of an inch would be the proper breadth, after the second sleep one-tenth of an inch, after the third sleep two-tenths or three-tenths of an inch, and after the final sleep only the stocks and berries need be removed and the leaves coarsely cut.

(49) The feeding of the worms does not altogether depend on the state of the weather, for before and after each sleep and just before being fully developed they neither eat fast nor much. The time the worms eat the fastest and most is the two or three days between each sleep, and during this period they should be fed oftener.

(50) In rearing silk worms the more rooms there are the better. Should there be but few, then prepare more trays in which to put the silk worms, and place these into proper frames or presses.

(51) The paddy ash, the straw whisks, the fuel (the latter must not be of a smoking nature), the cleaned, dry wheat, the bricks, etc., for preparing the inclosure, and all other necessities should be in readiness beforehand.

(52) The refuse of leaves and the *ts'an sha* (excrement of the worms) are not useless articles. Put them into a pit dug in the ground for the purpose and soak in water, and when decomposed they make a good fertilizer, either for the mulberry trees or other plants.

(53) Rats are passionately fond of silk worms, so people rearing them should not be without cats.

(54) Silk worms want to be quiet, and dislike noise; so do not allow people to disturb them.

(55) Silk worms dislike scent; such articles as vinegar bottles, wine jars, medicine pans, or anything that may have a smell, should not be put near them. Ladies tending on silk worms should not wear scented bags.

(56) Silk worms dislike tobacco. If tobacco smoke is puffed at them, they will eject a yellow liquid from their mouths.

(57) Paint and varnish are injurious to the silk worms. So do not put newly painted or varnished articles near them.

(58) Never put silk worms on paper with characters on.

(59) Although the cultivation of the mulberry tree is mainly for rearing silk worms, yet it is no loss if it is not cultivated for that purpose. For, when one hundred trees are full grown, they will yield from 20 to 30 piculs of leaves. Each picul is worth 1,000 cash. Neither drought nor overflow need be dreaded. It brings a lasting profit, accompanied by little labor.

(60) When one has more worms than he has leaves to feed them, he should ascertain the amount still needed and bespeak it beforehand. Arrangements should be made as to the time the picking is to commence (say from three to five days after *li-hsia*), and if the necessary arrangements are not made, the purchaser may want to keep his leaves longer; then there will be no end of trouble. The price of mulberry leaves is hard to fix; a figure agreed upon before picking will generally be a most satisfactory one. The keeper of silk worms must not delay ordering leaves for the mere chance of a better bargain later on, but must bear in mind that at times the price of leaves reaches as high as 2,000 or 3,000 cash the picul. On the other hand, the mulberry farmer must not delay selling his leaves with the hope of getting a better price, as a picul of leaves sometimes is only worth 100 or 200 cash.

DIFFERENT SHAPES OF SAW TEETH AND THE WAY THEY CUT.

THE accompanying sketches show the different shapes of saw teeth and the way that they cut the timber. Fig. 1 shows the dress of a shingle saw tooth. By

FIG. 1.—THE "DRESS" OF A SHINGLE SAW TOOTH.

examining it, it will be seen that it is a "sprung tooth," and the teeth cut on alternate sides of kerf, taking two teeth to clear out the kerf on both sides. The bevel of the teeth gives it a shear cut on the timber. The wood will slip on the edge of the teeth, wearing them on the inside and leaving the outer corner full and sharp, and a corner to clear up the side of the kerf, thus making smooth lumber.

Fig. 2 shows a square dressed tooth. The wood wears

FIG. 2.—A SQUARE DRESSED TOOTH.

off the corners, leaving them dull, and they will fly from timber to the other side if the wood is not equal in hardness, and lead the saw to that side of the log. This trouble is found in wood with a hard and soft grain or in knots, but with the beveled teeth the sharp corner will lead the saw straight. Fig. 3 shows a vertical saw with square teeth, a very common dress. The

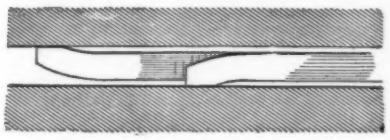


FIG. 3.—A VERTICAL SAW WITH SQUARE TEETH.

wood wears the out corner off, leaving it round or blunt, and as there is nothing to support the inside of the teeth, they will fly from the wood, and in the up stroke of the saw wear against the side of the kerf until worn in the shape shown in cut.

Fig. 4 is a swaged tooth of the same kind of saw and

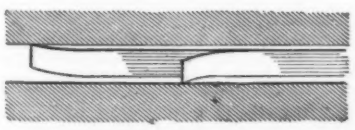


FIG. 4.—A SWAGED TOOTH OF THE SAME KIND AS FIG. 3.

is a very good dress for sash, muley, gang, and other saws using light feed, but for heavy feed it is better to swage the teeth out on both sides and joint off for set. By referring to Fig. 5 it is seen that all teeth of this shape cut with a scrape cut, not with edge cutting, like

FIG. 5.—TEETH THAT CUT WITH A SCRAPE.

a chisel, but with the edge set at right angle with the line of cut. For soft wood, such as white pine, hammer the top of the teeth, turn the edge down enough to give a cutting edge downward. Figs. 6 and 7 are circular log saws.

Fig. 6 shows a side view of a tooth. It is seen that the back of the tooth lies close to the wood, and the tooth may be filed thin without danger of breaking.

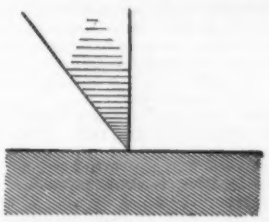


FIG. 6.—SIDE VIEW OF CIRCULAR SAW TOOTH.

This dress of saws, cut with a chisel cut, will carry more feed than any other, and at the same time do the best of work.

Fig. 7 shows the shape of the edge of the same tooth. It being hollow on the edge, with the corners sharp, the wood will fly or slip from the corners, not wearing them as much as a square tooth, leaving a good corner

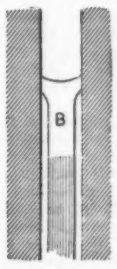


FIG. 7.—EDGE OF CIRCULAR SAW TOOTH.

to clear the sides of the kerf. It will be seen by referring back to Fig. 1 that it takes two teeth, one on each side of the saw, to cut both sides of kerf, but in this dress each tooth cuts both sides, and again, if a beveled sprung tooth is forced to do more than a medium amount of duty, it will fly into the wood and be in danger of tearing off the teeth.

In Fig. 8 is seen a square dressed tooth. All teeth

FIG. 8.—A SQUARE DRESSED TOOTH.

swaged with a square dress leave the corners rather weak and not much to joint off the side in setting. This shows one such tooth cutting through cross grained or twisted timber, a sharp corner but nothing to clear the side of the kerf, the cross grain filling so much of the kerf as to rub on the plate of the saw and heat it.

Fig. 9 refers to a dress for hand and other saws that

FIG. 9.—DRESS FOR HAND AND OTHER SAWS.

is used for cross-cutting soft wood that is to be cut very smooth.—*Saw-Mill Gazette.*

SPIRALLY WELDED STEEL TUBES.*

By JAMES C. BAYLES, Ph.D.

THE ideal pressure tube is, obviously, the one which combines the greatest strength with the least weight of material consistent with the uses for which it is designed or employed. The inside of the pipe is the first concern of the engineer. It should be cylindrical, smooth, and of the requisite capacity for the purpose in view. It should be in lengths as great as can be conveniently handled, so that the couplings may be as few as possible. With the walls of the tube the engineer has no further occasion to concern himself than to make sure they are adequate to carry the internal and external pressures to which they will be subjected.

It is as true of a pipe as of a truss, that, when it is strong enough to give the requisite factor of safety, nothing is gained by having it stronger. Anything more than this means dead weight, which has to be paid for many times, first as material and again and again in the costs of transportation and handling until it reaches its place in the trench or on supports. In use it must be and remain tight against all leakage, and must sustain whatever is placed over or upon it, or suspended from it, without deformation or injury. Finally in addition to meeting all the immediate requirements of service, it must possess qualities of durability which warrant a reasonable expectation of a long life of usefulness. The wise engineer no longer regards it as reasonable to depend upon mere bulk of its own material for the protection of a metal as readily impaired or destroyed by oxidation as iron or steel.

The metal must have a coating which will be and remain impervious and indestructible. When all these conditions are met, we have as near an approach to the ideal tube as can be attained with the materials now available for their manufacture. Steel used constructively, to the best advantage, meets these requirements most perfectly. Gold alone would do it better. If we search through the whole list of metals and alloys, we find nothing available which so perfectly meets the requirements as a pipe material as steel.

Mr. Hamilton Smith, jun., in a paper on the expedients adopted on the Pacific coast in the extensive schemes of hydraulic engineering, for which that part of the world has long been famous (*Transactions of the Iron and Steel Institute*, vol i., 1886), thus states the conclusions to which his observations have led him:

"The ideal conduit for high pressure is a welded steel tube. Such tubes could probably be subjected to a tensile strain of 25,000 lb. with perfect safety, and would be much preferable to riveted pipe, not only on account of superior strength, but also by reason of almost perfect interior smoothness. The adaptation of a superior and cheap metal, such as mild steel, for conduits, will permit the construction of hydraulic works in many parts of the world which now appear to be impracticable, owing to the cost of many of the methods now in use for the transportation of water."

The accuracy of this generalization is not surprising, considering the opportunities afforded Mr. Smith for the study of this question, where substitutes for the hitherto impracticable light welded pipe of iron or steel have been used most extensively and successfully.

The manufacture of light steel tubes by the processes employed in making the heavy tubes to which we have become accustomed has been found impossible for mechanical reasons. With the weight of metal needed to carry a welding heat from the furnace to the rolls, the pipe produced is necessarily heavy. Hence the extensive employment of riveted pipes during the past few years, not only on the Pacific coast, but all over the world, and of which the best that can be said is that they have been used simply because nothing better was available.

Some twenty years ago an ingenious American engineer and mechanic, the late John B. Root, conceived the idea of making light and strong tubes by spirally winding bands of iron or steel, so that the edges should overlap, and of heating the overlapping edges and welding them together during the forming process. The novelty of this idea consisted in confining the heat to the edges to be united, and welding the seam as the pipe was formed. The obviously greater strength of a tube thus made over one having any form of longitudinal seam had already attracted attention.

Many years before, as appears from English Patent Office records, an attempt had been made to produce a pipe having a helical weld. The blank was wound cold with overlapping edges, and placed in a furnace to be heated. When the welding temperature was reached it was drawn out, and an attempt was made to weld it on a mandrel by the pressure of rolls, externally applied. The experiment, though interesting, was hopelessly impracticable. To carry a welding heat from the furnace to the rolls, the material operated upon needed to be of a gauge so heavy as to render it impossible to cold-wind it. Furthermore it was impossible to keep the diameter uniform, as with every turn of the skelp it gained in size an amount equal to the thickness of the metal used. The problem was not at all akin to that of making the twist gun barrel, and after it was found that tubes could not be made in this way, the experiment was abandoned.

When Mr. Root began his experiments he probably had very little idea of the difficulties involved in accomplishing what now seems so simple. He began by cold-winding, and his first invention in this line was one which has had great value. I refer to the spirally riveted pipe. The machines for making this form of pipe, though never quite automatic, were very ingenious, and have done good service. They wind the metal, punch holes in the overlapping edges, and as the rivets are dropped in by hand, head them by compression. The process is obviously limited to the use of small and soft rivets, which can be "upset" cold by compression sufficiently to hold them in place. That pipe thus made has any greater utility than ordinary stove pipe is due to the fact that its seam is so disposed that it is not readily opened by an internal pressure exerted circumferentially. This form of riveted pipe is made of material too light to be calked; consequently it depends for tightness wholly upon the coating of zinc or coal tar given it. As a preservative coating for either iron or steel, zinc has little value, but it serves very well as a solder to stick the lapped edges together, and make a riveted pipe tight against any pressures not exceeding the strength of the material at the line of the rivets. The black coating, when properly made and applied at a temperature sufficiently high, also answers very well to close the seam against light pressures. In some places this pipe has rendered excellent service, in others it seems to have failed conspicuously. I presume its life depends largely upon how it is laid, and upon a light and measurably constant pressure. From its construction I should not expect it to stand shocks without developing leaks. As a matter of fact, however, the spiral riveted pipe has been largely employed, and it is still manufactured extensively.

During some ten years Mr. Root continued his experiments amid many discouragements. It was not until 1883 that he succeeded in building a machine which in a rude way demonstrated the practicability of making pipe from strips of iron wound spirally, heated along their overlapping edges only and united by hammering. This machine, which is carefully preserved as a mechanical curiosity, is a marvel of ingenuity, but not at all practical commercially. Mr. Root had throughout made the mistake of supposing that he was dealing with a mechanical problem simply. That he overlooked the chemical factors is evident to those who, after his death, took up his work and made it successful. It is true, however, that he produced some pipe in short lengths, and that, owing to the slip of the feed and other mechanical defects in his machine, some of this pipe was of surprising smoothness and beauty. That very little of his experimental pipe was really welded was due to

* A paper read before the Iron and Steel Institute, New York, 1890.

causes for which, as a mechanic, it probably did not occur to him to look.

At Mr. Root's death, which occurred before he had fully worked out the problem to which he had devoted so many years of patient labor, it was found desirable to depart radically from the lines of his experimentation, and to supplement his work by original investigation in many directions. For the purposes of this paper it is sufficient to describe the method of manufacture now employed, which represents the present state of the art.

The only material now used in the manufacture of spirally welded tubes is mild steel. This is at once stronger, cheaper and more uniform in quality than any iron available for the purpose, and owing to its homogeneity and density it resists destructive oxidation much better than iron of fibrous texture. Either Bessemer or open hearth steel is used. The specifications as to composition are not arbitrary. Phosphorus is not considered, being low enough in any steel yet tried. The carbon must be so low that the metal will not harden or become brittle when as suddenly as possible cooled with water after the weld is made. The sulphur must not be high enough to defeat welding, and copper must not be present at all. The steel employed has an average elastic limit of 35,000 to 40,000 lb. and an ultimate strength of 55,000 to 60,000 lb. Anything conforming to these very general specifications has been found to weld satisfactorily, and make excellent tubes.

The steel is rolled to the required gauge in sheets which will square 20 feet long, and is slit into bands 12 inches or 18 inches wide. Theoretically, there would be an advantage in establishing and maintaining a fixed relation between the diameter of pipe and width of skelp, but in practice it has been found wise to use two widths only for the diameters thus far produced. Tubes of 6 inches, 8 inches, and 10 inches diameter are made from skelp 12 inches wide; those from 12 inches to 24 inches diameter are made from skelp 18 inches wide.

A skelp in 20 feet lengths is not long enough to make tubes of the length most convenient for use and economical for shipment. The strips are united by welding the ends together. The machines for this purpose are simple in construction and operation, and do their work very rapidly. The resulting weld is so smooth as not to be visible in the finished pipe. As the stock is thus prepared by what is known as "cross-welding," it is reeled and passed to the tube machines. By this means the pipe maker is rendered independent of the limitations of the rolling mills, which, in the gauges demanded, cannot, with present appliances, advantageously roll more than 20 feet lengths. So cheap and rapid is the cross-welding process, however, that it is doubtful if any advantage would be found in having the strips longer. They would be more costly to transport and handle. The fact that, with cross-welded stock, tubes 100 feet long have been made, and that if it was of advantage to do so they could be made 500 or 1,000 feet long, shows how little the pipe maker is dependent upon the rolling mill manager. It is, however, useless to make pipes exceeding in length existing facilities for transportation. Thirty feet is the average car length, and on certain patterns of platform cars 32 feet can be loaded. To exceed this length would be to increase the difficulties of transportation and handling far more than the value of the couplings saved. The cross-welded stock is passed to the tube machine, and one end is laid on the guide table, which, being adjustable, is set to the angle due to the width of skelp and the diameter of the pipe to be made. On this table are the feed rolls, geared together, which draw the stock into the machine and pass it forward. As the skelp enters, it moves across the face of an anvil horn, which is rounded to conform to the shape of the pipe. The curvature of the stock is effected by the movement of an oscillating jaw, which presses the metal against the face of the anvil. The impetus of the feed rolls is intermittent, moving the metal forward when the shaping jaw is raised, and leaving it at rest when pinched between the fixed and moving parts of the shaping mechanism.

The source of heat is a small furnace of cast iron, scarcely more than a cubic foot in dimensions. This furnace is lined with refractory material, having passages of such shape as to deflect the gas and blast where they are needed. The furnace contains two or more blowpipes, as may be required. The fuel is a gas of a quality never before employed in any metallurgical operation. It is composed, as nearly as may be, of equal parts of hydrogen and carbonic oxide, is free from carbonic acid and sulphur compounds, and has a flame temperature of 3,80° Fahr. It is delivered to the machines under a considerable pressure, and mingles with the requisite volume of blast at the point of ignition. The practice in burning the gas, as in making it, is different from that followed anywhere else, so far as I am aware, but it has been found to be the one best adapted to the special requirements of the industry.

Heating and welding are, of course, the only elements of the process involving any particular difficulty. The nature of this problem can be judged from the fact that it required more than two years of very costly and anxious experimentation, in directions in which previous experience furnished no guide. To pass cold steel into a flame in which iridium will fuse, bring it from atmospheric temperature to that of welding in about five seconds, weld it and quench it with water at once, without burning the metal or producing any appreciable scale, is a metallurgical operation of great delicacy, and one which demands that all the conditions shall be right. If the flame assumes an oxidizing character for an instant, the weld is missed; if the stock binds, the feed slips, or for any other reason the steel remains in the heat an instant longer than is needed, it will run as fluid as water and make a hole in the pipe. When I say that a confident operator, who understands the conditions under which he is working, will often leave his machine and attend to something else while it is making pipe at the rate of 18 to 24 inches per minute, the perfection of the machine and process will be appreciated. It is not, however, so automatic that the operator can leave his machine with entire safety. With a constant pressure of air and gas, it would only need to be started right to finish a pipe without further attention. But as machines are started and stopped, producing slight variations in the engine speed, and, for other causes, the pressure of air and gas varies, the operator needs to increase or diminish the speed of his feed. This is accomplished by a modification of the link motion, which enables him, while the machine is running, to stop the feed altogether, or increase it so that it shall drive the skelp forward at the rate of more than 200 inches a minute. The average running speed in pipe making advances the skelp from 90 to 100 inches per minute. I have no doubt that further improvements in the plant will make the process so nearly automatic that, after the operator has run out a foot or two, he need give his machine no further attention.

It is essential that the gas and blast should be as perfectly under control as the feed. There are always two edges to be equally heated—one at the end of the already formed pipe and the other the edge of the flat or entering skelp which is about to be added on. For this reason the operator must be able to vary the proportions of gas and blast in each blowpipe. This he can do without leaving his position or abandoning the lever by which he controls the feed mechanism. The direction of present experiment is to make the pressure of gas and air so constant that the operator, having ascertained the proper rate of feed, can let one reel of skelp follow another with no concern for his product unless something breaks.

The machine having these complex functions of feeding, heating, welding, and discharging the pipe, is quite simple in construction, and has but few working parts. It is of unusual interest to see cold skelp drawn in, heated, shaped, welded, and passed out as finished pipe, at the rate of a foot to two feet per minute, with all the operations by which flat steel is converted into pipe, performed within a space which could be covered by one's hat. I venture to say it is wholly unlike any industrial process to be seen in this or any other country.

The welding is done under a light hammer, which strikes about 320 blows per minute. The hammer is so arranged as to give what is known as a dead blow. The weld thus secured is vastly superior to that attainable by the pressure of rolls. A hammer blow can be delivered at the mouth of the furnace, and does not rob the metal of the heat necessary to produce a perfect union. Pipe can be made without the hammer, by the contact of the jaws which bend and form it, but the hammer is more certain. The welds produced by hammering are as perfect as are ever made on the anvil by a skilled blacksmith. Test pieces subjected to tension show that the metal tears before the weld separates. As the direction of the weld is such that, under pressure, it is never subjected to a strain tending to open it, it serves as a spiral re-enforcement, and pipes made by this method, unless they show a leak in the initial test, can be depended upon to develop a strength equal to the ultimate strength of the metal composing them. The spirally welded pipe is an illustration of the best constructive use of material known in the arts. It is, in fact, stronger than a seamless drawn steel tube of the same diameter and thickness of wall.

The weight of steel used in making spirally welded tubes ranges from No. 14 to No. 6 B. W. G. The diameters now made include all sizes from 6 inches to 24 inches, and will probably be extended to include smaller and larger sizes. The limit in small diameters is that which will admit an anvil horn stout enough to withstand the heat and hammering to which it is subjected, and remain rigid under the compression of the shaping jaw. There is no limit in the direction of large diameters except such as is imposed by the present difficulty of obtaining stock of suitable widths and lengths, and the cost of transporting large and light cylinders. When the demand for pressure tubes of larger diameter than 24 inches shall justify provision for their manufacture, there will be no difficulty in making them.

After the pipes leave the machines the ends are squared on a trimming machine, and they are tested in the usual way. They are then provided with their couplings, and are finished by dipping in a bath of Trinidad asphalt. The coating is hard, insoluble, and extremely tenacious, and as a protection against rust is very durable.

This industry has scarcely been established long enough to have a history, but it has experienced a very rapid development. Its product has gone into every use for which pipes of diameters of 6 inches and upward are employed. They are in successful use as steam and compressed air conduits, gas mains, water pipes, petroleum lines, and to some extent in architectural and engineering constructions. In mining operations they have met every requirement of service—the saving in transportation charges often amounting, at remote and inaccessible points, to a very large item. They have also been found useful for many purposes for which timber has hitherto been employed—as in trestles, tramway trusses, supporting columns, etc. A 12 inch tube, 30 feet long, with couplings, which would be safe under a working pressure of 500 to 700 lb. per square inch, will weigh, according to the thickness of metal used and the coupling provided, from 475 to 490 lb. Thirty feet of lap-welded tube, 12 inches in diameter, will weigh not less than 1,700 lb., and 30 feet of 12 inch cast iron pipe, strong enough to carry a working pressure due to a head of 100 feet, and lighter than that usually demanded in water works construction, will weigh from 2,700 to 3,000 lb., and perhaps more. The spirally-welded steel tube certainly has a range of utility greater than that of any tube previously known, and it places at the command of the engineer a material which broadens his field of operations in all directions, and renders practicable undertakings of great magnitude which have hitherto seemed impossible on the score of cost.

BRICK MAKING ALONG THE HUDSON RIVER.

THERE are between $4,000,000 and $5,000,000 represented in the brick industry in the territory along the Hudson River embraced between Haverstraw and Grassy Point, N. Y., which gives employment to something like 4,000 men. The firms who are interested there are Josiah Filter, H. Christie & Son, Thomas Shankey & Co., P. Lynch & Son, P. Lynch, D. Fowler & Son, the Excelsior Brick Co., A. Donnelly & Son, T. Frederick, James Dolan & Co., T. Maguire & Sons, R. Murray & Morrissey, Archer Bros., Sherwood & Baum, Snedeker Bros., T. G. Peck & Co., B. J. Allison & Co., Bennett, Rowan & Scott, Wood & Keenan, the Diamond Brick Co., Allison, Wood & Keenan, D. Fowler, Jr. & Co., Thomas Dinan, T. C. Maguire, R. Crowley, Washburn & Co., Carr & Smith, P. Morrissey, P. Brophy, Barnes & Farley, Thomas Mailey, G. G. Allison, Mary Buckley, Allison, Wood & Allison, Reilly & Rose, Reidley & Clark, D. Tompkins & Son, C. A. Marks & Bro., P. Goldrick, James Brennan, F. Ohler, Clarke & Goldrick, Fowler, Washburn & Co., and Thomas Shankey & Son.

While there are but forty-odd firms, there are something like seventy-five brick yards, some of the firms maintaining from two to six establishments. It is not always the case, either, that the firm owns anything but the sheds and paraphernalia incidental to their business, and not always the former of these essentials. In many instances the property is rented, upon which the firm pays a royalty to the owner of the lands (and frequently the structures) of from sixty to seventy-five cents per thousand bricks. This would seem to be an exorbitant rental and out of all proportion to what one would be led to believe the property was worth in that vicinity. What could have been more surprising than to have our representative informed by President Washburn, of the People's State Bank in Haverstraw, that the land along the river there was valued at from $15,000 to $25,000 an acre.

IN THE YARDS.

Of course there is a difference in the size and construction of the buildings in the various places, and more or less machinery in use. Still, to properly fit up one of the brick yards necessitates the expenditure of from $30,000 to $60,000, and in many cases more than this latter sum has been expended. The firms that I have mentioned furnish the market with something like three hundred and fifty to four hundred million bricks a year. In order to place them upon the market—and that means to deliver them—it is stated approximately that between sixty and seventy barges are in constant use, besides from thirty to fifty sloops, which are in a great measure owned by the brick manufacturers, or controlled by them at all events.

The old English plan of building the kiln of bricks is still pursued, as it was in the time of Henry VIII., and although such splendid kilns as the Dunnachie, the Eudaly, and the Morrison kilns are in use in other parts of the United States, the Hudson River brick manufacturers cling to the old style of burning, which is much to their loss.

What is called a fairly good brick clay, such as that at Haverstraw, consists of about three-fifths silica, alumina one-fifth, and the salts before mentioned one-fifth—the greater the proportion of iron, the redder in color the brick after being baked.

Work begins in the spring as soon as the frost is out of the ground, and continues until frost sets in again. The clay pits at Haverstraw are within a few hundred feet of the sheds, and the clay, after being dug out with spades, is carted to a circular trough where it is thrown in in layers with one-third sand and a small proportion of coal dust—one bushel to sufficient clay for a thousand bricks. The sand is for the purpose of hardening and solidifying the baked clay after it has reached a state of fusion and becomes cool. The coal dust is simply to increase the heat. It is consumed during the baking and is given off in gases.

The sand and clay are deposited by the carts in the "pits" in the rear of the sheds, when, mingled with anthracite coal dust, it is fed into the moulding machines. The introduction of coal dust into brick stuff was the ingenuity of John Wood, the first Haverstraw brick maker. A man at the foot of the moulder thrusts into the machine a frame containing spaces for six bricks, which spaces are first sanded by an improved brick mould sanding machine, made by A. H. Newton, Cohoes, N. Y., which, being quickly filled, is placed upon a small truck. When thirty bricks are placed upon the truck, it is wheeled away to have its load laid upon the ground, emptied and returned for another load.

The moulding machines have a capacity of twenty-one thousand per day. The capacities of the different yards regulate the number of kilns and machines; in fact, the number of kilns is at the pleasure of the proprietors.

The moulding season begins with the opening of spring weather, an early spring insuring an early beginning in this branch. Moulding generally begins about April 20 or April 25, and lasts until the middle of October. After this period a small force of men continue to work under the protection of the sheds.

The brick moulds used measure 8×2¼×3¼ inches, inside measurement. After being moulded the bricks are either put on a pallet (a flat board), wheeled off in a barrow and placed in wooden racks, or are put edgewise in rows on the ground. At Haverstraw, sheds protect the newly made bricks from rain.

While the freshly made bricks are drying, a boy passes over them a machine called an "edger," which turns six bricks at a time on edge, and he is followed by another boy, who, with a "spatter" in hand, presses it upon the bricks to give them perfection of shape. Sufficiently dried to permit handling, the bricks are "hacked," or stacked on either side to more thoroughly dry.

When this stage has been reached, the bricks are ready for burning. Removed again to the sheds whence we see the smoke arising, the bricks are built into an arch-shaped but solid kiln. About forty five thousand are "packed up" in regularly shaped piles of forty-one bricks in height.

This is the most important part of the whole process. The bricks are piled up edgewise, the first layer being covered by the second transversely, and the second by a third transverse layer, and so on until the kiln is completed. It is then about twenty feet in height, thirty-two feet in width and eighty-five feet in length, with the bricks one-half inch apart. At intervals of four feet or thereabout apertures two feet wide, extending the entire width of the kiln, have been left, where fuel can be put in and fired. These apertures are called "arches," and each arch has about it 45,000 bricks, so that in a kiln eighty-five feet long, containing twenty-one arches, there would be within 5,000 of 1,000,000 bricks. An extra wall of brick is then built outside the kiln, and this is carefully plastered over with wet clay, so that every crevice is covered. Then the baking be-

gins by starting a fire in each of the arches simultaneously. This is fed by cordwood being tossed in by the kiln men, who become wonderfully expert in landing the stick at any part of the arch desired.

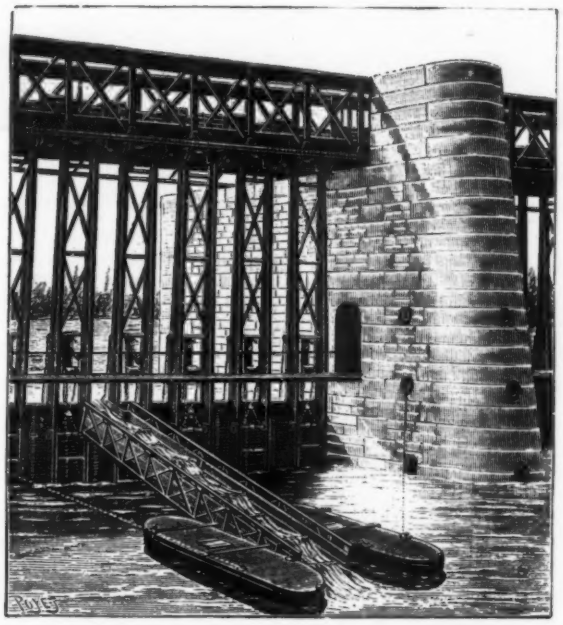
All the Haverstraw men work on the "task stint" labor principle, earning from $1.75 to $4 per day. Foremen receive from $4 to $6 per day, averaging throughout the year about $1,200, although one of the concerns has paid its foreman $1,500 a year. Although the Haverstraw and Grassy Point establishments employ three thousand or more men, the majority of these are transients and reside in that town only during the six or seven months of their employment. Ira M. Hedges, who was a candidate last fall on the Republican ticket for State Treasurership, is the president of the National Bank of Haverstraw, and largely interested in the manufacture of bricks. Mr. Hedges is almost the sole owner of the Diamond Brick Co., besides holding a quarter interest in the Excelsior Works, at Haverstraw.—*The Brickmaker.*

MOVABLE FISH CHUTE.

THE improvements made in rivers, from the standpoint of navigation, may sometimes prove prejudicial to the interests of pisciculture. Engineers should not lose sight of this question, which is of much importance.

Stationary or movable dams installed upon rivers have the evident inconvenience of forming an absolute obstacle to the passage of migratory fishes, such as the salmon, etc., which ascend rivers at certain seasons of the year. To overcome this difficulty, chutes were installed, in the first place, under cover of the abutments of the dam, but this arrangement was afterward found to be insufficient.

We propose to make known to our readers a system of fish chute which is movable with the level of the water. Its arrangement, due to Mr. Caméré, is particularly interesting. Stationary chutes installed under cover of the abutments of the dams have always had the inconvenience of not being much frequented by



MOVABLE FISH CHUTE UPON THE SEINE.

migratory fishes, which prefer places where the water is deeper and swifter, and so it is better to install the chutes in the center of the deep channel of the stream. Mr. Caméré has succeeded in getting up movable chutes of iron plate or wood that rest at the down stream end upon a float and at the up stream end upon the edge of the movable shutter. We thus have an installation of great simplicity, which has the advantage of offering no fixed structure capable of interfering with the fish, and which, besides, can always be transported to the most favorable situation.

The chute herewith represented is of wood, and formed of two parts. One of these rests at one end upon the float and is hooked at the other to a bar in front of the uprights of the dam, thus permitting it to oscillate according to the variations in the level of the down stream water. The second part, which fits into the other, runs between the uprights of one of the frames of the dam. The length of the chute is determined in such a way as to give an inclination of 1 to 20 for the maximum depth of the impounded water. The principal part is 33 feet in length. The length of the chute outside of the frames is five feet, the spacing, from axis to axis, of the transverse partitions is four feet, and the height of the latter is 16 inches. At the crossing of the frames of the dam, the smaller part of the chute rests upon the upper slat of the shutter. Down stream, it fits into the main part and rests upon it through a rounded surface that permits of oscillations. The upper slat of the shutter must always be lowered to a level sufficient to assure of the operation of the chute, and the space thus made is closed by special gates arranged here and there along the uprights of the frame occupied by the chute. The bar to which the principal part is attached is held and kept immovable by chains hooked to the uprights of the dam.

The chute is removed or re-established according to requirements, by a series of maneuvers that we shall not dwell upon, as they may be at once understood from an inspection of the figure.—*La Nature.*

REVOLVING CYLINDER ENGINES.

THE mechanism of a direct-acting engine consists of a piston reciprocating in a cylinder secured to a fixed frame, a crank shaft revolving in bearings arranged in the fixed frame, and a connecting rod jointed to a crank pin on the shaft and to a pin formed in the

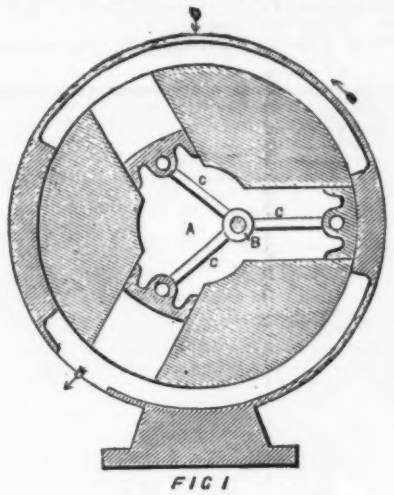


FIG 1

piston or piston rod. During a complete revolution of the crank shaft in its bearings, the crank pin makes a complete revolution in that end of the connecting rod to which it is jointed, and the other two joints, the piston in the cylinder and the pin in the tail end of the connecting rod, reciprocate through a limited stroke and a limited angle respectively. This disposition of mechanism always seems to be indirect on account of introducing a reciprocating piston, when the motion of a revolving shaft is the object to be attained. Many efforts are continuously made to obtain direct action, but none seem to effectually attain their object. Among a crowd of efforts of various characters, one principle seems to be attaining an increasing popular-

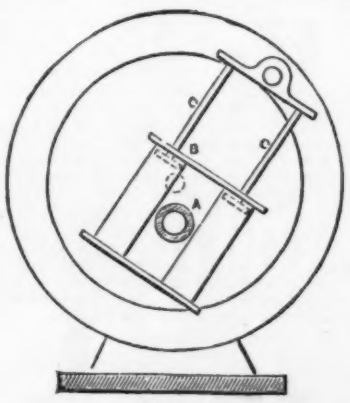


FIG.3

ity; on it are constructed what may be termed revolving cylinder engines.

Two shafts or frames are arranged, which revolve around two parallel axes a little apart, and are coupled together by a piece which reciprocates respectively to each; generally one of the reciprocations is rectilinear and the other angular. Though very different in appearance, yet these engines bear a close analogy to the ordinary fixed cylinder engine. In fact, the complete cycle is the same as in that engine, but its order relatively to the fixed frame altered. If, instead of arranging that the link or frame which holds the cylinder and main bearings be fixed, we arrange that the crank arm or frame which contains the two revolving pairs shall be fixed, then we come at the pattern that forms the subject of this article. Supposing this to be done, we have that which was the fixed frame making a complete revolution relatively to the now fixed crank arm,

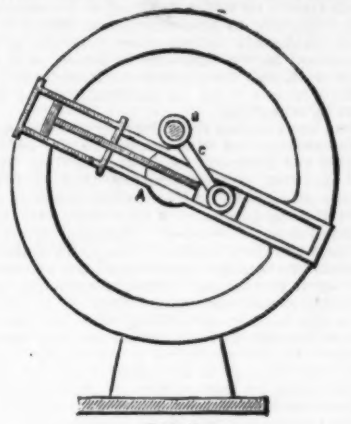


FIG. 2

and that which was the connecting rod making also a complete revolution to the crank arm. These two revolving pieces are coupled together by a piston or reciprocating piece, which moves backward and forward in a straight line relatively to the one, and backward and forward through a limited angle relatively to the other.

Some such constructions may be readily understood by referring to the accompanying sketches. Fig. 3 is an engine brought out some time ago by Mr. Mills, and consists of a cylinder frame A revolving round an axis, and holding two cylinders symmetrically placed as shown. The pistons of these cylinders are connected by piston rods to a common crosshead, the center of the crosshead being jointed to a pin fixed to a circular frame revolving about a center B. In this instance the cylinders revolve absolutely about the center A, and the pistons approximately about the center B. They would revolve absolutely about that center if the crosshead were rigidly attached to the frame B and they were shaped with a spherical surface where they pair with the cylinder, and thus accommodate themselves to the various obliquities imposed upon them. Fig. 4 is an example invented long ago by Mr. Ward, and is on the same principle. This engine has one cylinder, whose axis is placed so that it directly radiates from the center round which it revolves.

Another engine is of very similar character, devised by Mr. Benham, and differing but little from it, except that as many as eight cylinders are constructed in the cylinder frame, these radiating directly away from the center of revolution. The above arrangements are sometimes varied by radiating the cylinders toward the center of the cylinder frame, instead of outward. It requires no explanation to see that the main features of such mechanism are precisely of the same character. Figs. 1 and 2, the Morey engine and the Cary engine, are examples. The similarity of parts can be followed by the lettering, which is used in each to indicate the same parts. Many other engines have been invented in this direction, and based upon other mechanisms, though all possess the peculiarity that piston and cylinders revolve round centers.

The above rearrangement does not at all alter the character of the mechanism, though at first sight it might appear as though all reciprocation had been eliminated.

The close analogy which has been shown to exist between it and the ordinary direct-acting engine would cause such a claim to be looked upon with suspicion. In these engines the piston, though revolving, reciprocates relatively to the revolving cylinders with which it is paired, and hence the necessity, in the new engine as in the old, to alternate the action, first in the one direction to send the piston to the opposite end of its stroke, and then in the other to return it to its original position.

Though this return be effected by making the cylin-

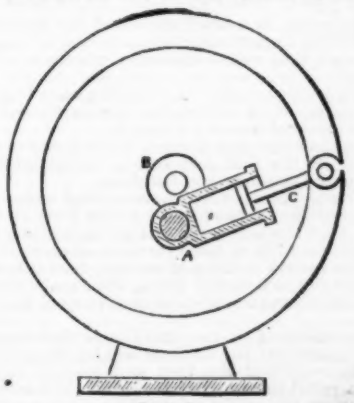


FIG.4

ders double-acting or by adding another single-acting cylinder, another peculiarity of reciprocation exists, that of dead points at each end of the stroke. The defect arising from this can only be counteracted in the new engine as in the old by adding extra cylinders with their gear, and thus no particular advantage is gained.

Some of the revolving cylinder engines are so de-

signed by giving them suitable proportions and disposition of parts that it would appear that a third peculiarity of reciprocation is done away with, that of absorbing power to overcome the inertia of the reciprocating parts. This, considered from a point of view of wasting power, is no defect, for that power which the reciprocating piece may absorb during the first part of its movement or during the time its velocity is being accelerated relatively to the piece to which it is paired, is restored again during the latter part of its travel, or while its speed is correspondingly retarded relatively to the cylinder in which it works. The evil that this action does produce is that it throws a recoil in the opposite direction to the force acting upon it, and this, being communicated to the fixed frame, causes it to be unsteady, or at least to subject it to vibration.

As it has been shown that altering the disposition of the engine mechanism with respect to the earth does not obviate the necessity of counteracting the main essential features of reciprocating, that is returning the reciprocating piece to its original position and the existence of dead points, so it may be shown that this evil of recoil is not alleviated. Take any one of these engines, say the Cary engine. Here the cylinders revolve round one common center, and the pistons round another, each having an absolute revolving motion, but a relative reciprocation. That is to say, with respect to the fixed frame holding the two main centers, these pistons have a revolving movement, but with respect to the cylinders a rectilinear reciprocation, and with respect to the other frame or eccentric frame, an angular reciprocation. Considering only one cylinder and its fittings, which is sufficient to eliminate all the characteristics of reciprocation, if, as is asserted, no reciprocation exists, it will hardly be disputed that the piston, relatively to the cylinder in which the steam acts, moves with a varying velocity. There is no difficulty in seeing that it will vary from zero at one end of its stroke to zero at the other end, the intermediate variations depending upon the proportions of the engine. It will vary, in reference to the cylinder, exactly in the same way as the piston of an ordinary engine, whose length of crank is equal to the distance between the centers of the improved type, and whose length of connecting rod equals the distance between the center of eccentric frame and center of pin on this frame, to which the piston or its rod is jointed.

This being so, if we consider the action when the steam enters the cylinder, and is starting the piston off from one end of its stroke, we shall see that the steam pressure acting on the piston will not be fully communicated to the pin on eccentric or wheel frame, but will be diminished by the amount required to start the piston off at its original acceleration. This is not modified by the fact that cylinder and wheel frame are revolving round fixed centers. The action of a force in setting a body in motion is determined only by the movement produced in the direction in which the force acts. Though the piston goes round in a circle, the force keeps up with it, and is always acting in the direction of the piston's motion; and hence has some of it absorbed when the velocity of piston is increased in that direction, and is restored again when decreased. The result is therefore, at the moment under consideration, that there are two forces acting on the fixed frame through the centers—one equal to the steam force acting at the back of the cylinder, the other a smaller quantity, depending upon the rate at which the piston is accelerated. Thus the fixed frame, at this instant, is under the action of the difference of these forces, and hence will tend to move or, if secured firmly, to vibrate.

Such engines may, however, be balanced, but exactly in the same way as ordinary fixed cylinder engines; that is, by adding extra cylinders with their gearing, and so arranging them that the irregularities of the one may be counteracted by those of the others. There would seem to be no way of avoiding the evils of reciprocation, whether return stroke, dead points, or recoil; but all of these may have their evil tendency counteracted. In some of the examples quoted, as for instance Riggs, it cannot be disputed that they do run with exceeding smoothness, even though the cylinders may not be arranged to produce perfect balance. This may be accounted for by considering that the weights of the revolving parts are great in comparison with the weight of the reciprocating parts, and thus the evils of reciprocation are deadened, or smothered over. Given, however, a perfectly balanced fixed cylinder engine; or given an imperfectly balanced fixed cylinder engine, with a substantial fly-wheel, the result should be as satisfactory.—*The Engineer.*

MILITARY BALLOONING IN FRANCE.

THE following is a brief sketch of the grand maneuvers that have just taken place: Let us imagine a hostile army that wishes to occupy the plain of Thiérache, situated between the Sambre and the Meuse, and which is a prolongation of the Ardennes. This plain, which is a hundred and eighty meters in altitude, is the most elevated one of the region.

The hostile army was covered by an army corps (represented by the first and second corps) which was moving on Le Quesnoy and Cambrai.

The French forces were concentrated under shelter of the intrenched camp formed of La Fère and Laon Places. One French corps (the second) protected the concentration with a large force of cavalry. To this effect, the second division of independent cavalry had come from the environs of Paris, with its batteries, in order to re-enforce the brigade of cavalry of the second corps.

The encounter of the two army corps that formed the advance guards of the adverse armies took place between the sources of the Oise and Escaut—that is to say, at a point intermediate between the two plains.

The review took place on the 18th, at the end of the maneuvers, between Niergrices and Sevanvillers, five kilometers to the southeast of Cambrai.

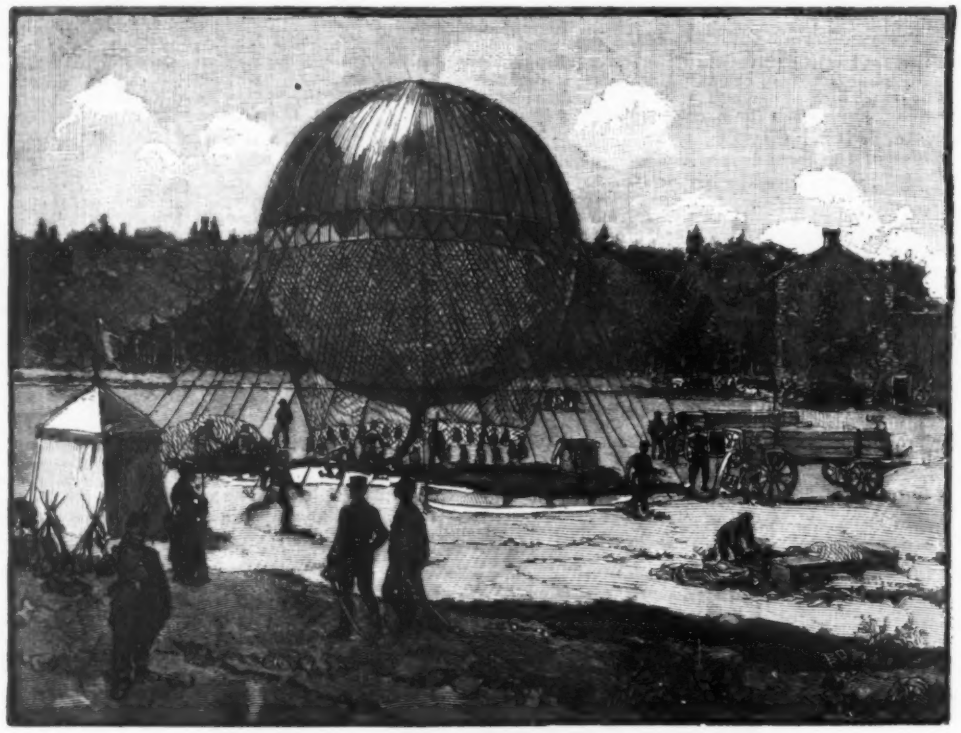
Without giving a complete detail of the operations that succeeded each other, we shall merely borrow from an interesting letter some comments upon the sketches that we give herewith, and which illustrate the most important of the maneuvers of the first and second corps of our army.

The wagons of Captain Aaron's company of military aeronauts were parked at the entrance of Solesmes, a little village situated at a distance of nineteen kilometers to the northeast of Cambrai. Here, in a field, were arranged eight large wagons, each carrying eight cylindrical steel reservoirs superposed in two rows, and containing the hydrogen necessary for inflating the balloon.

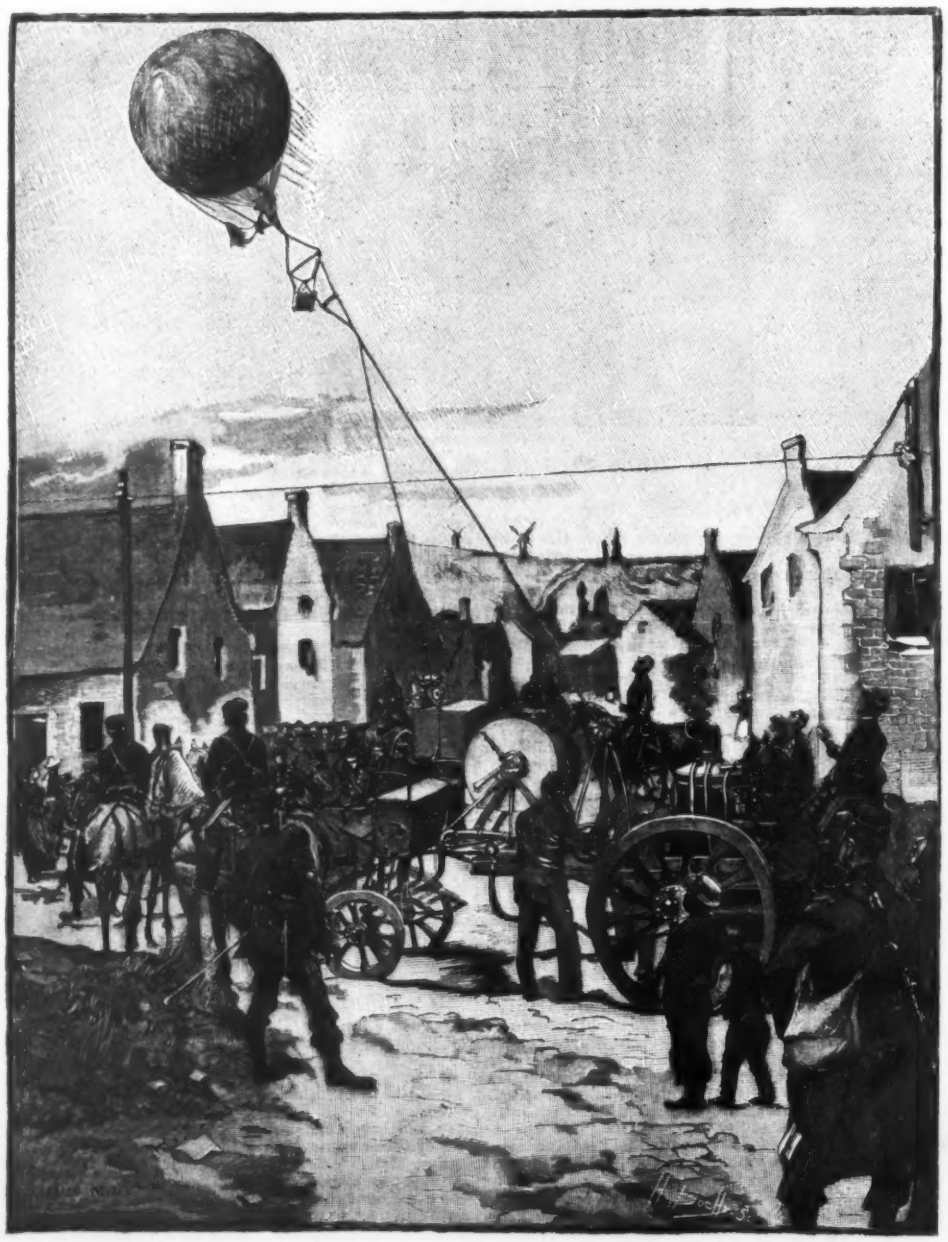
The experiments began on the 9th of September. At the command of Captain Aaron the reservoirs were opened, and the gas, escaping with a noise, inflated the balloon in less than half an hour. The balloon was made of Chinese silk and had a capacity of 540 cubic meters.

The aeronauts were gloved and shod in canvas, so as not to damage the silk of the balloon in manipulating the latter.

After the balloon had reached a certain height, the brigade began to attach to its base the osier car. This was 1·5 meters square, and was provided with two folding chairs to seat the two officers who were to occupy it, with leather pockets containing the apparatus and



INFLATION OF THE BALLOON.



MANEUVERS OF A COMPANY OF BALLOONISTS OF THE FRENCH ARMY.

maps, and with a telephone, of which the wire wound around one of the two cables that attached the balloon to the windlass of the carriage.

The balloonists then let go the equatorial ropes and grasped the maneuvering ones, by means of which they hauled the balloon to the carriage to which it was attached. The engineer at once set the steam engine in motion, the windlass revolved, and the balloon ascended to a height of 80 meters, and was kept at that altitude.

The double door of the inclosure was opened. "Forward, march!" exclaimed Captain Aaron; and the carriage, drawn by six powerful horses, and containing three artillery chiefs, then started, preceded by a wagon provided with a strong pulley at its extremity. —*Le Monde Illustré.*

LACEY'S SEA ANCHOR AND OIL DISTRIBUTOR.

UNDER the provisions of the English Merchant Shipping (life saving appliances) Act, 1888, all vessels are required to carry sea anchors and oil distributors in their life boats. Messrs. Manwell & Glen, 8 Great Winchester Street, London, E. C., are introducing a combination sea anchor and oil distributor, invented by Mr. R. G. Lacey, which we illustrate below, Fig. 1 showing it as attached to the thwart, and Fig. 2 when opened. The apparatus consists of a square of stout rot-proof canvas, A, attached at the top to a stout spar, B, and weighted by a galvanized iron rod sewn into the canvas at F F. At C is a pocket containing a flat copper vessel, secured by a lacing up, D. This constitutes the

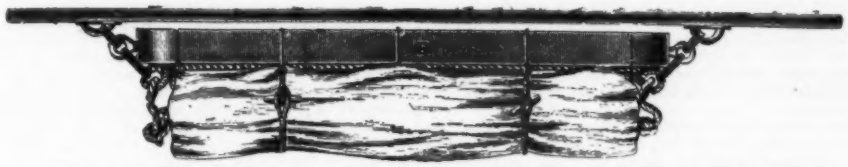


FIG. 1.—VIEW SHOWING METHOD OF ATTACHMENT TO THWART.

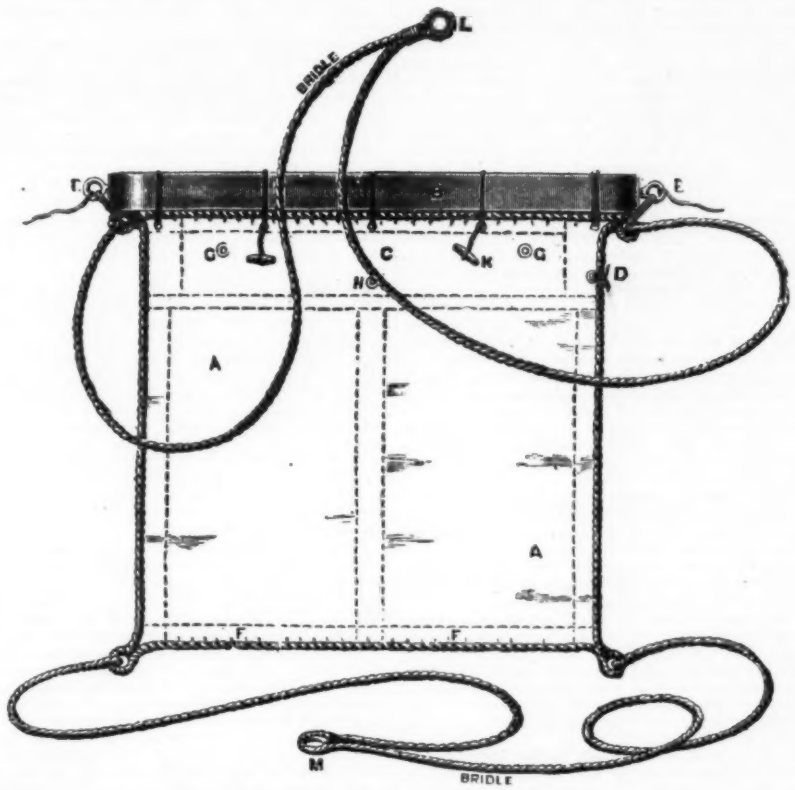


FIG. 2.—APPARATUS WHEN OPENED.

IMPROVED SEA ANCHOR AND OIL DISTRIBUTOR.

oil holder and distributor. At G G are screw plugs, which, when unscrewed, allow the oil to escape slowly, and as it flows out it is replaced by water entering a similar orifice at H. E E are eyes for stretching the anchor on the spar and for suspending the apparatus to the thwart, and K K are toggles for gathering up the canvas and bridles when the anchor is not being used. The spar, B, is proportioned so that it floats the entire anchor, including the copper vessel filled with oil or water and the iron rod which acts as a sinker.

In using the anchor the boat rope is taken through the thimble, L, in the upper bridle, and is then fastened to M in the lower bridle. By attaching another smaller line to the thimble, L, the anchor can be readily tripped at any time, it being only necessary to haul upon the smaller line and slack out the boat rope, and this feature of the invention is of considerable importance.—*Industries.*

FERROID, A NEW ARTIFICIAL STONE.

By HERMAN POOLE, Member of the Civil Engineers' Club of Cleveland.

FERROID, as its name suggests, is like iron—in color, expansion and many other properties—and contains proportions of that metal varying from 25 to 33 per cent. It is a compound, partly chemical and partly mechanical, of the elements of iron, sulphur and silicon, with more or less foreign matters; and from the union of these elements a material is obtained having some properties of each of its constituents, besides others possessed by neither.

It is mainly a super-saturated solution of iron in the sulphur, with the silica acting as a binder and hardener. The form of the crystals is entirely different from that of sulphur or iron in any of their states, and the melting point is midway between that of its constituents.

Before mentioning any of the uses it may be well to give a succinct account of some of its physical and chemical properties, as by so doing a fuller comprehension of such uses and applications will be possible.

Color.—The usual color is that of a dark slate. This color is lighter on a fractured or coarsely tooled surface and much darker on a polished or varnished one. It then approaches black or plumbago color. Being thus of a dark color naturally, attempts to make light tints are futile, but many colors of a medium tint are possible, besides the darker ones. The pigments used must be of a kind not affected by the action of sulphur; of such nature are the earthy pigments which work well, although, being of weak tinctorial power, large proportions are needed.

Imitations of the color of various kinds of brick and sandstone have been successfully made, also the various mauves, dark drabs, slates, dark greens, etc. These tints and the natural one being of the neutral kind harmonize well in combinations and can be used to produce very pleasing effects.

Hardness.—The hardness is comparable with stone and brick, and is about that of ordinary bluestone. It is quite tough for the class of material, being capable of working under hammer and chisel, drill, or even being turned in the lathe or planed with a planer. It is thus much tougher than ordinary cements and most artificial stones. The colder it is, the tougher in working.

Surface.—The surface is smooth or rough as desired, depending on the proportions of the materials used, and much more on the surface of the mould in which it is cast and the character of the finish imparted to it. Any of the different styles of finish may be given it which are applied to cut stone, even to a polish as smooth as glass; in fact, the polish of plate glass may be easily transferred to it, and on microscopical examination all the fine scratches are shown reproduced on the ferroid.

Elasticity.—The elasticity is slight but measurable, the elongation under tensile strain very low. Resistance to tensile strains is quite high for the class of material; strains of from 750 to 1,200 pounds per square inch having been resisted in test pieces of one inch sections. It compares very favorably in this respect with the natural and artificial stones as well as the cements. It possesses the advantage of uniformity in composition, and hence it is possible to have large quantities with the same strength.

Compressibility.—The compressibility is very slight, but resistance to compression is high, being from 9,000 to 12,000 pounds per square inch in test pieces 3 in. square; in one instance 15,000 pounds per inch was sustained, without crushing. This enables it to hold successfully as large weights as can be applied to any of the stones used in building, and places it far beyond the strength of the common cements in use, as few of them ever equal the strength of the stones they are used to bind.

It shows no tendency to bend under pressure, and breaks with a columnar fracture.

Adhesion.—It is very adhesive to anything that presents points of contact and to many substances which are nearly smooth. It will adhere to glass and glazed surfaces while hot. The force of adhesion to brick, stone, wood or iron is that of several hundred pounds to the inch; to cast iron, the strongest of any.

This adhesion to cast iron is shown in the case of a conical cast iron plug being cemented with ferroid in a ring of cast iron. The thickness of the cement varied from one-half to one inch and the diameter of the plug was six inches. A force of 150,000 pounds was applied without starting it or even showing any signs of compression.

This adhesion is manifested also under transverse or shearing strains in brick and stone joints. In the case where ferroid was used as a cement for pavement blocks one of the stones was broken by a sledge hammer in futile attempts to drive it through.

In another instance, thirty-two ordinary bricks were cemented together side by side, and supporting the two end bricks on props, a weight of 150 pounds was held up at the middle. The whole was then supported while the end brick was cemented to a wall, and on taking away the supports the line not only remained unbroken, but the deviation from perpendicular to the wall was hardly appreciable.

Although ordinary liquids have no adhesion to a smooth ferroid surface, viscid, oily substances adhere well and can be spread smoothly. The surface thus becomes available for many applications needing oil paints, in fact, it forms one of the best surfaces for oil painting and many times has been used for such purposes—a fine, smooth painting being the result. In many of the uses in a large scale this property becomes convenient, as lettering or painting of more or less of the surface is often desirable, in some cases indispensable.

Porosity.—Having a solid, uniform, homogeneous texture, water or other liquids, and even air or gases, have no passage into or through it. The thickness of one sixteenth of an inch has repelled a pressure of twenty pounds of water. A polished surface presents a firm front like polished steel to all attempts of liquid penetration, and one on which they get no hold, and through which a pressure of 300 pounds to the inch has been unable to force them. This applies to steam pressure as well as air pressure, a force of 80 pounds steam with its accompanying temperature having been successfully sustained.

Weight.—The specific gravity is about 2·6, being thus one fourth as heavy as lead or one third as heavy as iron.

Ordinary sandstone will float on melted ferroid, although it becomes nearly submerged when all the air is expelled from its pores. The weight varies a little with change of composition, but it is safe to estimate 1 cubic foot as 170 pounds, 1 cubic inch as 0·1 pound, 1 flour barrel full as 600 pounds.

Action of Heat.—It is a very poor conductor of heat, the thickness of $\frac{1}{24}$ inch being sufficient to protect the hand from danger of burning from the melted ferroid, or even from a temperature of 400°. This property is also shown in the use of the material in taking casts from the moulds.

It melts at about 300°, and melts very slowly at first, requiring a low fire. This is owing to its low conducting power. When melting it is necessary to keep it well stirred, especially at first. Later on an occasional stir will suffice. At the first application of heat no softening occurs until the melting point is reached. Then it melts to a thin liquid, nearly as thin as water, and remains so if the heat is not increased. On increasing the heat a gradual thickening is noticed, until finally it becomes as thick as mortar, or even thicker, and can be stirred only with difficulty. If, now, it be allowed to cool, a gradual thinning occurs until the former watery consistency is attained. This it keeps until solidification.

While solidifying, the whole mass becomes a conglomeration of feathery, leaf-like crystals intricately woven together. This crystal structure is entirely different from the sulphur crystal, and undoubtedly is the cause of the high tensile strength. On cooling, a gradual contraction takes place, as with cast iron, until the whole mass is nearly solid. Then a slight expansion occurs, followed by a small contraction as it gets cold.

The expansion seems to be occasioned by the whole mass assuming the crystalline form, and the subsequent contraction is that due to the general law of expansion and contraction. The contraction after setting is about that of cast iron, slightly less.

Action of Electricity.—Being a non-conductor of heat, it would be supposed to act in a like manner toward electricity, and such is found to be the case. Tests made with bars of ferroid 14″ long, 1½″ wide and ¾″ thick showed a resistance of ∞, ∞ and 125,000,000 ohms. This test was made after the bars had been soaked in water for 36 hours. These tests place it in the front rank among insulators, along with vulcanite, shellac, etc.; in fact, places it ahead of them.

Action of Air, etc.—Gases having no apparent adhesion to ferroid surface, if smooth, have no action on it, and pieces exposed to the action of the weather for several years have shown no diminution of polish. The effect of ordinary climatic changes is not to disintegrate it, as for this it is necessary for moisture and its winter form of frost to penetrate the mass. This it cannot do, and consequently has no effect beyond a blurring of the polish, which is readily removed with wiping. Rain striking it glances off as from an oiled surface. Usually, the capillary attraction of water in a vessel of ferroid is exerted in the negative direction, as with mercury in glass, the meniscus being reversed.

Mixtures.—Ferroid can be mixed with almost anything which is dry. Any of the earthy materials, sand, gravel, rubble, clay, lime, brick dust, dried earth, etc., work in well. Some of them seem to have no effect on the strength, unless used in very large proportions.

It is capable of uniting very large proportions of sand or gravel without sensible diminution of strength. The earthy or fine materials weaken it more.

Asphalt, tar, sulphur, and like materials can be in-

corporated with it, some needing more care than others. The resulting mixture is between the elements in properties, and some of these mixtures are very valuable. With tallow and fatty matter no mixture can be had.

Applications.—As may be readily supposed from the above recital of the properties of ferroid, the applications are numerous and valuable. A few only will be mentioned.

First. Let us consider it as a material capable of melting, and hence of being cast in a mould.

This is possible with almost any kind of a mould, moulds of glue, plaster, wood, stone, and metal having been used. Moulds of sand may be used, but it is not ordinarily desirable, as the surface is very rough, and owing to the tenacity with which the sand is held, it is very destructive to tools used in dressing.

Ferroid is probably the only hard substance which can be melted and poured into a glue mould without spoiling it. This has been done repeatedly and with complicated forms. The action is peculiar. Of course, the glue melts with the heat of the ferroid, but before this occurs a thin skin of solidified ferroid has been formed on the surface of the mould, which, by its strength, prevents the liquid mass from breaking through, and by its low conduction prevents the glue from melting quickly. The glue is hence held in place and melts very slowly, and by the time the glue is melted soft, the ferroid is set and hard enough to bear its whole weight and keep the glue in place. On cooling, the glue recasts itself on the ferroid, and when quite cold it may be stripped off as good as new.

With plaster moulds and also with wooden ones care must be taken to avoid air bubbles, or blow holes, as these become magnified in the cast, owing to the expansion of the air under heat. This does not apply so forcibly to metal moulds, as they are generally comparatively smooth.

With all moulds except those which are highly polished the use of some greasy or waxy material is necessary, owing to the strong adhesiveness. Paraffine wax or heavy lubricating oil seems to answer the purpose best. Only enough need be used to prevent contact, as more would blur the impression. In some cases plumbago or facing may be used, either alone or supplementary to the wax or oil. Even with highly polished surfaces it is well to have a very thin film of oil, which is best obtained by lightly wiping over with an imperfectly oiled rag.

In making hollow casts some provision must be made to remove the core from contact with the solid ferroid before the contraction sets in. In conical or conoid moulds this is easily effected by withdrawing the core slightly—an inch or so being sufficient. With other forms collapsible cores must be used.

When making casts it is usually advisable to heat the mass above the melting point, with brisk stirring. Then remove the vessel and let it gradually cool down till of the proper consistence for pouring.

It must be remembered that whatever form is made it can be used over and over again, as remelting does not deteriorate but rather improves it. All broken pieces are as good for remelting as new material.

Among small objects may be mentioned the numerous statuettes, vases, medallions, picture frames, etc., to be found in our drawing rooms, and *insulators* for telegraphic or other electric wires. These latter may be cast smooth or with thread, either inside or outside or both, and being hard cool, not acted on by the elements or chemicals and of high resistance, may be used to advantage in all places where an opaque insulator is admissible. One was tested in the office of the Western Union Telegraph Company, at New York City, by being placed in water, the inside being dry. A force of 10,000,000 ohms was needed to pass the current through the sides, which were ⅛" thick in thinnest part.

Mugs, Pitchers, Cocks, Tubes, etc., which are in constant use in chemical works, may be made of ferroid and do good service.

Battery Tops for closed cells and the numerous other places where vulcanite or its equivalents are used can be supplied with ferroid at a decided reduction in cost, but no reduction in insulation.

Among larger castings may be mentioned *pipes* for sewage or other purposes. It is eminently adapted for this use, requiring no skilled labor at the ordinarily difficult pieces and being capable of ornamentation in any way desired at no extra trouble in casting. As soon as the form is out of the mould it is ready for shipping and no delay in preparing, drying and firing is needed. The pipes are not porous and may be had polished if needed. They have no honeycomb structure and small bubbles due to defective moulds never extend into the body of the pipe. They can be cast in the ordinary or special shapes readily and are always of uniform strength.

Chimney Tops have been used in several instances and cost much less than any made from stone. They answer well and are very durable. The temperature at the top of an ordinary house chimney never reaches anything like the melting point of the ferroid. They may be made of very artistic forms as readily as of simple ones.

For black boards a very decided advantage over slate is obtained in price. They always have grit enough and do not get gummy. They can be put up much thinner than slate ones. They wear as long as the school house.

Billiard Table Tops are cast with smooth top and bottom, and require no polishing. They resist the usage well and cost much less than slate.

Sanitary Appliances, such as water closets, urinals, basins, bath tubs and the like, have been made and possess many advantages. They are clean, almost self-purifying. They are not porous and furnish no foothold for disease germs. They are cheap.

Vats and Tubs.—Can be used for any purpose, water, chemicals or electro plating. They may be made with or without holes or taps and can be changed as desired, holes being easily stopped up or drilled out.

Architectural Forms.—Caps, cornices, sills, keystones, corners, bricks, whole arches, in fact, or columns may be made, either in moulds or *in situ* if needed.

Many other forms could be mentioned that will readily suggest themselves to a practical man.

Core makers, having intricate cores to make, have occasionally availed themselves of ferroid by making a model of the core in wax, wood or plaster and pouring ferroid over it. A mould is thus made which will outlast many of the ordinary wooden ones.

Occasionally blow holes or sand holes are found in cast iron, and in some instances to save breaking the casting these holes were filled with ferroid. In one instance, in a trip hammer block after being painted over, it not only did not show, but six months' wear did not loosen it.

Second. Having considered the applications depending on its melting, let us now consider some which come from its adhesive properties in addition.

In this connection attention is at once drawn to its immense advantages as a building material for concrete, etc., any kind of stone, any kind of gravel may be used and it will unite them so firmly that in many instances the stones themselves will break before leaving the cement. Of course, any application of concrete of any other kind can be filled by this with the proviso that the materials used and the surfaces applied be dry at the time of the applications. Once thoroughly united, no water or moisture will ever get in, and hence no crumbling from such cause.

A very large amount of filling in the shape of sand or broken stone and gravel may be used without weakening the mass, as it seems that only ferroid enough to unite the stones firmly together is needed, no especially large body of cement being required.

Any desired form may be given the concrete by means of suitable moulds and it may be moulded into blocks or used as a continuous mass *in situ*.

Culverts and Bridge Foundations may be cited among the numerous applications of this concrete and the surface imparted to them may be rendered perfectly smooth, thus lessening the friction of the water, and in the case of culverts enabling a small cross section to be used. They are as strong and durable as stone, and have no attraction for moss germs or other vegetable growths, which have a tendency to choke up the openings.

Another form of concrete is that used in making floors for stables, breweries, chemical works or other places requiring a strong, hard, durable, impervious floor, not affected by heat or cold, rain or shine, steam, moisture or ordinary chemicals.

The same or analogous composition used for floors may be used as a facing for walls. There are many cases where a wall has been laid with ordinary mortar or cement, and the water on the outside persists in going in or the inside persists in going out through the wall. An application of ferroid made plastic with a large quantity of sand will remedy this. If the surface of the wall can be made dry or approximately so the ferroid will stick to it, and once on no further trouble will be had from water on either side. In this way leaky cisterns, vats, chimneys and other brick work may be rendered tight. It will stick to wood, but not as firmly as to brick or sandstone.

As a simple cement, it has been applied to joints of sewer pipe and some kinds of water pipe with success. In one instance, a line of water pipe had 300 pounds of water turned on in fifteen minutes from the time of pouring the joints and no leak discovered; of course with ordinary kind of ferroid no calked joints can be made. With iron pipe uniform success has not been attained, but this will probably be had with a better understanding of the material, and how to use it.

It has been used as cement for bricks in many places. Its strong adhesion to this class of material was shown above. The outside course of ordinary chimneys has been laid with it, and in the case of that portion projecting above the roof very good results have been attained, especially in locations where strong winds tend to overturn them.

Allied to this class of structures may be mentioned towers of brick erected for chemical purposes, for which it is well adapted by its strength, absence of pores and resistance to chemical action.

Underground cisterns, vats, cellar walls, and the like, when laid with it have the advantage of its strength, and eminently its non-absorbing properties.

Several thousand yards of stone pavements have been laid using ferroid as a cementing material, and after several years' use but slight wear can be noticed. Its high melting point added to its not softening under that temperature gives it a very decided advantage over other substances used for such purposes. It does not get brittle by cold. It is non-absorbent, germ destroying, clean and durable.

It requires a force of 400 pounds to the inch of surface contact to shear a stone out of its bed, and in many cases efforts to drive one out with a sledge hammer have resulted in fracturing the stone, but not starting it. As it wears a little faster than the stone, a good foothold is always possible for the horses.

RESULTS OF TESTS MADE.

The majority of these tests were made at the testing department of Fairbanks & Co., New York City. Some of the others were made with Riehle & Co.'s machines.

No.	Composition.	Kind.	Pounds per in.
1.	Ferroid	Compression.	9,073
2.	1 ferroid, 3 sand	"	11,308
3.	1 ferroid, 3 sand, 6 stone chips,	" (sideways.)	3,756
4.	Ferroid	Iron ring compression,	15,000
5.	Ferroid	Tensile,	750-1,050
6.	1 ferroid, 3 sand	"	850
7.	1 ferroid, 1 asbestos	"	1,050
8.	Ferroid	Transverse,	1,322
9.	Ferroid	Adhesion to iron,	526
10.	Ferroid	" stone,	431
11.	Ferroid	" brick,	420
12.	Ferroid	Pressure (steam),	75
13.	Exposed to action of gas in main. No action on the ferroid.		
14.	Boiled in dilute sulphuric acid. No action.		
15.	Boiled in muriatic acid. No action.		
16.	Boiled—mixture of soap suds, niter, and soda. No action.		
17.	Electrical resistance	125,000,000 ohms.	

—*Jour. of the Association of Engineering Societies.*

THE FOOD OF MAN IN RELATION TO HEALTH AND LONGEVITY, IN THE LIGHT OF COMPARATIVE DIETETICS.

By Frank Woodbury, M.D.

The old puzzle, "Is it better for a man to have a dinner and no appetite, or an appetite and no dinner?" is still unsolved. In another shape it reappears in the familiar nursery question, "Is it better to be a beggar by day, and at night dream of being a king, or to be an actual king, and every night be pursued by dreams of beggary?" In this case the verdict is usually rendered in favor of the enjoyment of the substance of royalty rather than dependence for happiness upon the shadowy stuff that dreams are made of. This problem, however, or one analogous to it, is actually presented by civilized man in comparison with uncivilized races, or the lower animals. The latter are blessed with appetite, good digestion, and an uncertain supply of food, while highly civilized man, with abundant food, eats with little appetite, and oftentimes lacks the digestive power to easily and comfortably dispose of the food with which the art of the cook has succeeded in seducing his palate. Where the greatest luxury prevails, the so-called culinary art reaches its highest development, and gastronomy becomes a science. Here also the question, "how to get an appetite for the dinner," often becomes more pressing than "how to obtain the means to satisfy hunger and support life."

Such conditions and customs are not favorable for determining what is the best diet of man. If we wish to ascertain his most natural food, we must go to communities in which greater simplicity of life prevails, and where occupations impose conditions less obnoxious to physiological laws than those pursued in large cities. Here we may find the finest developments of bone and brawn, and also discover how with simple food good digestion may wait on appetite and health on both.

Comparative dietetics, or that department of comparative physiology which considers the problems arising in connection with the food supply of the lower animals and their relations to those of man, has shed much light upon the physiology of digestion and nutrition, and can also render valuable aid in solving still unsettled questions. Comparative anatomy and comparative physiology have thrown side lights upon many obscure problems in human anatomy and physiology, which, without their assistance, would have remained unelucidated. In a similar manner, comparative dietetics may be made to contribute important information which will most materially advance human dietetics, and assist in selecting new articles of food and in defining more clearly the requirements of a suitable dietary for man.

In general terms it may be said that the presence of life is conditioned upon the exercise of the functions of absorption and assimilation of various food materials.

When a living organism is under normal conditions, these functions maintain its physical integrity, and enable it to go through its cycle of development in accordance with its physiological law. When they have finally discontinued their operations, the organism perishes.

By the presence or absence of these functions, therefore, we can easily distinguish between organic and inorganic substances, a distinction by the way which has been made since the earliest times. All living substances, during their period of existence, therefore demand regular supplies of food material in form and character suitable for absorption and assimilation.

Among the lowest forms of life, we observe the greatest simplicity in this respect. Indeed, the rule is that only one kind of food or pabulum will support the organism and permit its growth. Thus we have well known forms of micro-organisms that develop only in certain chemical solutions, such as the *micrococcus ureæ*, causing the ammoniacal fermentation of urine, the micrococcus of mucoid wine fermentation, the micrococcus causing phosphorescence in putrid meat and fish; the bacterium lactis, causing lactic acid fermentation in milk, and the bacterium aceti, associated with acetic acid fermentation. Advancing in the scale we find nearly every variety of vegetable product accompanied by a parasite to which it affords the appropriate food.

Even the higher animals in their natural state have a very limited variety of articles from which to select, and which affords them all the nourishment needed for their growth. In a state of domestication, the effects of different kinds and of greater variety of foods have been carefully studied both physiologically and economically, and biological science has been enriched by the results of innumerable investigations, since Boussingault first opened this important field of investigation. At the present time stock raisers know how to feed so as to produce fat, or on the other hand so as to increase muscle and bone. Special traits of form or color may thus be cultivated, and in fact, according to Darwin, all the existing varieties of domestic animals are the result of man's controlling agency, especially in the direction of methodical selection and feeding.

These facts are common knowledge, but they demonstrate the far-reaching and important relations of food, and are suggestive in regard to the diet of man.

One distinguishing feature by which the dietetic problem in man differs widely from that of the lower animals is the absence in the latter of the gastronomical element. The animal eats its appropriate food with relish, and as long as it thrives seeks no change from year to year and from generation to generation. Man, on the contrary, in his civilized state, demands an extended dietary, and tires of even the most wholesome and appetizing articles, even acquiring disgust for them, if too long continued. The anecdote of "*toujours perdrix*" is here very much to the point. We observe, however, that the animals nearest to man, living upon comparatively few articles of food, are very rarely troubled by anything like indigestion. It may be added that in drink they are still more restricted, and after weaning are limited to cold water. The contrast on the score of health between them and the lords of creation is not in favor of the latter. Possibly a hint may here be found which will suggest the cause of the difference.

Man in his uncivilized state resembles the lower animals in the poverty of his dietary and, under favorable conditions, in his physical health. Travelers who have visited tropical Africa state that the native tribes along the Congo exhibit some of the finest specimens of human development that they have ever seen. This may be partly due to the extinction of the unfit, which is a necessary result of their hand-to-hand conflict with nature, but it is also partly attributable to the simplicity of their diet, and also to their constant open air life and physical training.

If we extend our observations to "all sorts and conditions of men," we conclude that man may be properly styled an omnivorous eater. In various parts of the world the food and eating customs are peculiar. The Digger Indian prolongs a precarious existence by eating roots, bugs, centipedes, and almost anything that he can find to fill his not too fastidious stomach. The Esquimau can drink train oil with a relish, and enjoys eating brown soap and candles in the intervals of his feasts of whale blubber. The Indian of the Orinoco fills his stomach with fatty clay in place of something more substantial, and in fact the savage tribes of South America eat anything that will support life.

None of these, however, presents the high type of physical development that is seen among the Zulus of Central Africa, whose diet is chiefly sour milk and cereals. Among the Chinese, whose principal diet is rice, we find professional athletes that in physical strength can scarcely be equaled elsewhere, and laborers of unexcelled powers of endurance. They appear to have solved the problem of obtaining the maximum of results from the minimum expenditure in the form of food.

The capacity for work and the ability to endure hardship without the loss of health may be taken as a rough measure of vitality of a race, a family or an individual. One great defect in our higher civilization is that we have not given due regard to physical health. We have been so much interested in accumulating material wealth, and acquiring knowledge, that the necessity of the maintenance of health to a great extent has been overlooked. Children have education and inherit wealth, but the best legacy of all is too often neglected, and with an abundance of means they lack the healthy mind in the sound bodily frame that is essential to the full enjoyment of life. Fortunate are they if they find medical advisers who can direct them back to the physiological road, and so enable them to attain the highest degree of health which they are capable of enjoying. In the midst of wealth they may, by living like a beggar, enjoy reasonable health during the day, and also pleasant dreams at night. From the daily papers we learn that the late Mr. William Vanderbilt lived for many years before he died solely upon mush, and by this means was able to lead a fairly active life. He outlived many men of stronger physique, who fell victims to the pleasures of the table, a danger to which our upper classes are particularly prone to succumb.

The example and experience of the celebrated Cornaro, and also of many others who, by temperance and moderation in all things, have succeeded in attaining long life and in retaining their mental faculties unimpaired to a late period, demonstrate beyond dispute the importance of reducing the number and variety of articles of food, observing great carefulness in the use of stimulants, and avoiding dissipation of every kind in order to have health and longevity. It is very obvious that this is not the practice of the most of those by whom we are surrounded and with whom we come in daily contact. But then most men and women fail to attain advanced age, and indeed scarcely live to middle life.

The result of adopting a different course is to be seen in the career of the comparatively few around us who were wise in time, and who, by duly regulating their lives, have been enabled to enjoy existence, even beyond the traditional threescore and ten. This subject indeed has never been better summarized than in the celebrated dictum of the Salernian school:

"Just taste the rich repast, of wines abstemious be,
Thy palate keep in check, beware of gluttony;
Study the way of health, avoiding strife,
And so for many years thou may'st prolong thy life."

A general review of the subject of food throughout the animal kingdom shows that the primary object is to supply force to the living organism and material for its growth. A most important lesson just here for man to learn would be that his palate is an unsafe guide amid the perils of the table. A consideration of its truth has led a distinguished Frenchman to declare that "men do not die, they kill themselves by eating," or as another less elegantly expresses it, "they dig their graves with their teeth."

Comparing the individual articles of diet of civilized man with those of races who are only semi-civilized, one great difference is at once apparent—it is the enormous consumption of sugar (saccharose and glucose), which seems to be steadily on the increase among the former.

When we consider that among the ancients, whose achievements in art and literature still command our admiration, and whose heroic deeds we emulate, sugar was not used or known, and that among savage tribes presenting such perfect types of physical development it is also absent from the dietary, it is worth while to pause to ask the question: "Has this great addition of sugar to our daily food a beneficial effect upon health, or not?"

Such a change as the consumption of large quantities of sweet food must produce is either for good or for evil. Many physicians think that it is decidedly the latter. Dr. Dudley Reynolds, of Louisville, has, in several able articles, shown the dependence of catarrh and enlarged tonsils upon the use of glucose in the food, and insists upon its elimination from the diet as a condition of cure. It is not unlikely that consumption of the lungs is largely induced by the catarrhal state to which the excessive use of sugar may act as a predisposing cause, as improper food is known to produce the peculiar vulnerability of the organism specially favorable to the cultivation of the bacillus tuberculosis. Various forms of digestive disorder and caries of the teeth are popularly known and acknowledged to spring from this source. It is probable that it also has decided influence in developing rheumatic taint, and in the causation of eczema, neuralgia and diabetes. Food rich in sugar and starch is a cause of obesity, and reduction of these is essential in order to overcome this undesirable tendency to increase in weight without corresponding increase in bodily strength.

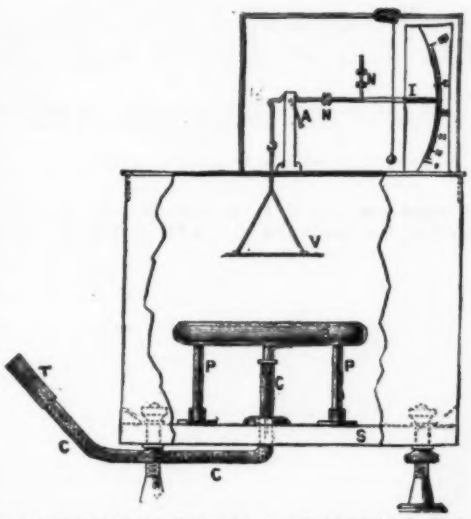
The diet of the higher races of man also differs from that of the lower animals, in the prominence given to what have been termed accessory foods, which do not directly build up the tissues or yield force to the system. The use of tea, coffee, tobacco and alcohol, as a part of the daily diet of civilized life, certainly must also exert marked influence upon the development of man. It cannot be doubted that in many cases this influence is evil both directly and remotely. This subject, however, has been abundantly considered in articles more comprehensive than this, and cannot be further pursued here. The object of the present contribution is merely to point to the fact that the highest physical and intellectual development of man can be attained by a diet from which these articles are absent, and so invite consideration of the question whether or not the practice of greater simplicity in diet, especially during childhood, would not be advantageous to mankind when its results are so evident among the lower animals.

To those who prize health above all other earthly blessings, this subject appeals particularly on account of its obvious relations to health and longevity. By the more intelligent class of patients the question is being constantly asked: "What shall I eat?" Fortunately, physicians are better qualified to-day to discuss the food problem in its relation to disease, and to give proper instruction and advice, than at any previous period in the world's history. To those who have given but little attention to the relations existing between food and health, and who wonder why they are frequently ailing, we commend further study of the physiology of digestion and nutrition. The warning of the founder of scientific medicine frequently recurs to the mind, and although over two thousand years old, is still appropiate. "Such constitutions as suffer quickly and strongly from errors in diet are weaker than those who do not, and a weak person is in a state very nearly approaching to one in disease."*—*Dietetic Gazette.*

THE ELECTROSTATIC BALANCE.

THE arrangement of the parts of Sir William Thomson's electrostatic balance is shown in the engraving. The fixed portion of the condenser in this instrument is a brass disk, B, which is supported from a slate base, S, on three glass pillars, P. The disk is provided with the well-known Thomson "hole, slot, and plane" arrangement, so that it always rests in exactly the same position on its supports.

A wire thickly covered with India rubber passes from a terminal, T, through a glass tube, C, C, C, and makes connection with the disk by a spring contact,



SIR WILLIAM THOMSON'S ELECTROSTATIC BALANCE.

the glass tube being filled with paraffin to prevent the lodgment of moisture and give great resistance to disruptive discharge. A sheath formed by a short piece of glass tube pulls up over the terminal, T, and protects it from being touched by accident. The slate base plate is provided with three screw leveling feet. A brass case fits upon the slate base plate, and fixed to its top is a metal scale box, with a glass front, which contains the indicator and scale. The movable part, V, is a round aluminum plate, supported by two long links, which pass through a slit in the top plate of the case to two knife edge stirrups on one end of the counterpoised indicator, I. The whole movable portion is supported by knife edges on two brass pillars, and has a short arm, A, with a knife-edge stirrup at its extremity attached to its axis. The weights which fix the constant of the instrument hang on this stirrup.

The instrument has a scale with divisions corresponding to equal differences of potential. The scale is graduated from 0 to 50, and three weights are provided such that, with the first alone hung on, the constant is 259 volts per division, with the first and second weights on, it is 500 volts per division, and with all three weights on, 1,000 volts per division.—*Electrical Engineer, London.*

M. FERDINAND CARRE.

GENERAL SEBERT, in presenting the report of the Comite des Arts Economiques to the Societe d'Encouragement pour l'Industrie Nationale, in which M. Ferdinand Carre's claims to the Henry Giffard prize of 6,000 francs for the most signal services rendered to French industry are set forth, observed that M. Carre's investigations in the artificial production of cold, and the manufacture of carbons for use in electric lighting, had had considerable influence on the industrial world. It was owing to M. Carre's investigations under the latter head that certain recent developments in electric lighting had been possible. The manufacture of carbons for electric lighting was at first by means of Foucault's method of pointing the carbons, a method capable only of producing an irregular and expensive article. This was in 1868. It was then that M. Carre, in a note addressed to the Academie des Sciences, pointed out a process by which some of the drawbacks of the Foucault process could be avoided. In 1876 he patented his drawplate method, to which he subsequently added improvements with a view to securing regularity and excellence.

These improvements included the composition of a carbonaceous paste and the choice of an adhesive liquid as well as ingenious processes for the burning, drying, and the impregnating of carbons under heat, by means of vacuum and compression; and it is due to them that the use of Jablochkoff candles has been possible. The sale of drawn carbons has been considerable from the outset. With a view to modify the tint of the arc and to get rid of the incandescent particles projecting from the superficial strata, M. Carre first devised a hollow carbon furnished with a core of different composition, next a process whereby the carbons were impregnated with various salts subsequently removed from the outer layers by solution, so that only the core remained impregnated. These improvements he patented in 1878 and 1886. He also succeeded in producing a carbon to give out red light. The fluted carbon, which is largely used in England, and was the subject of a patent in 1886, we also owe to M. Carre. Unfortunately, owing to these inventions not having been patented abroad, they are used without let or hindrance in foreign countries, and the inventor's profits are consequently greatly curtailed. But the services of M. Carre are freely acknowledged; and, in awarding the Giffard prize to him, the society is acting in accordance with the popular verdict.—*Electrical Review.*

A NEW RESIDUAL.

THE existence of cyanogen compounds in crude coal gas has been known for some years. In the Claus process, which was tried at Birmingham in 1886, and is in use in Belfast and other places at the present time, the recovery and profitable utilization of these substances is a special feature. Their existence, however, was regarded as an incidental matter. They were merely turned to account because they happened to be present. But on the Continent, especially in Germany, matters appear to have advanced a step farther. Not only is it sought to utilize the cyanogen matters, but chemists have pointed out that nitrogen, existing in the form of cyanogen, has a much greater commercial value than that obtained as ammonia. Attention is, therefore, being directed to the operations of distillation, and especially of purification, with a view of obtaining the largest possible proportion of the more valuable cyanogen compounds from the residuals.

In connection with the Claus process, Mr. Charles Hunt mentioned, in his paper read before the Gas Institute in 1886, that the spent liquor is found to contain sulphocyanide and ferrocyanide of sodium. The sulphocyanide is said to be derived partly from the bisulphide of carbon, but mainly by the reaction between cyanide and bisulphide of ammonium, thus:

$$NH_4Cy+(NH_4)_2S_2=NH_4CyS+(NH_4)_2S$$

The ferrocyanide is derived from the cyanide of ammonium by the action of the sulphide of iron from the iron of the apparatus. The ferrocyanide is decomposed first by the addition of a salt of iron, leading to the formation of Prussian blue (ferrocyanide of iron), which settles as a precipitate. The clear liquid is drawn off, passed through the sulphur wash tower in order that it may be charged with sulphurous acid, and a solution of sulphate of copper is added, which causes a precipitate of cuprous sulphocyanide. The clear liquid is run off as waste. One ton of coal was said to yield about ½ lb. of Prussian blue and 1¾ lb. of copper sulphocyanide. So far the progress of the cyanogen from its original combination with ammonium in the gas to the commercial products is rendered clear. It appears that the proportion by percentage is very small, as the finished products only represent 2¼ lb., or 0·1 per cent. of the weight of the coal. The additional profit due to the utilization of the cyanogen naturally claimed some attention in the discussion which followed the paper, and Professor Heaton pointed out that any cyanogen compound—such, for instance, as cyanide of potassium—could be readily obtained from the cuprous compound, while Prussian blue was in good demand. Mr. C. W. Folkard, after some experience in extracting cyanides from spent oxide, thought that it would be difficult to find a good market for any quantity of them.

Mr. C. W. Watts, in a paper read before the Society of Chemical Industry about six months later, referred to the existence in crude gas of cyanogen in the form of hydrocyanic acid. This is said to range from *nil* to 0·1 per cent. by volume, and to be removed in the scrubbers with the other impurities. Mention is made of the presence of sodium thiocyanate in the scrubber liquor; the sodium being derived from the caustic soda added to expel the fixed ammonia. In accounting for the action in the scrubbers, however, the hydrocyanic acid is assumed to be in combination as cyanide of ammonium; and the above equation is quoted to show the formation of thiocyanate—the same thing as sulphocyanide—of ammonium. Another source of sulphocyanide is referred to, and that is the spontaneous decomposition of ammonium thiocarbonate, thus:

$$(NH_4)_2CS_3=NH_4CyS+2H_2S$$

The total yield of sodium thiocyanate is put at 2·3 lb. per ton of coal; and this salt can be recovered by evaporation, or precipitated with copper as above described. In an article by Messrs. Watts and Heaton, which appeared in the volume of the *Journal* already quoted (p. 577), it is stated that the bulk of the cyanogen is found in the spent liquor as sulphocyanide of ammonium. The ammonia can be driven off by steaming with lime, carbonate of soda, or carbonate of potash. The liquid is mixed with a proper proportion of alkali, and naked steam is driven through it. The ammonia passes off to the saturator, and the residual liquor yields on evaporation the sulphocyanide of the alkali. If carbonate of potassium has been used, the resulting sulphocyanide can be converted into ferrocyanide (yellow prussiate of potash) by ignition with metallic iron. The yield of sulphocyanide of potassium is found at Birmingham to be 2·58 lb. per ton of coal used; and this would give 1·1 lb. of ferrocyanide, the net profit on which, after paying expenses, would be something over 2d.

* Hippocrates "On Ancient Medicine," Sydenham Society's translation. London, 1869.

At the 1888 meeting of the Société Technique du Gaz en France, M. Pendrié read a paper, embodying the results of practical research on this subject, which was subsequently noticed in the *Journal* (Vol. LIII., p. 1040). He concluded that, during the distillation, part of the ammonia originally formed was converted into cyanogen before it left the retort, and appeared in the products of distillation as hydrocyanic and sulphocyanic acids. Of these, the greater part was retained by the ammoniacal liquor, and the remainder passed on to the purifiers. According to his calculations, a ton of coal would yield about ¾ lb. of cyanogen, of which more than one-third would escape absorption in the scrubbers and washers. He stated that nitrogen in the form of cyanide is more valuable than when it is converted into ammonia; and he accounted for the formation of cyanogen in the retort by the following reaction:

$$2C+4NH_3=2(NH_4)Cy+2H_2$$

The ammonia coming in contact with red hot carbon combines with it; at the same time giving up one-third of its hydrogen, which goes to increase the bulk of gas.

In a contribution to a German scientific magazine by Herr J. V. Esop, to which attention was directed in our columns early in the present year, it is stated that cyanogen is present in spent oxide as sulphocyanates, which are soluble in water and alkalies, and also as ferrocyanogen, which exists in the form of a double compound of Prussian blue and ammonium ferrocyanide, insoluble in water, but soluble in alkalies. The whole of the former class might be removed by sufficient washing; and it appears probable that a very large proportion, if not all of them, were taken out by the Claus process at Birmingham. At the same time it is possible that they may escape the less searching action of washers and scrubbers, as applied in the ordinary way. The author obtained various quantities, ranging from 1 to 4 per cent., of sulphocyanic acid, and from 3½ to 9 per cent. of potassium ferrocyanide, from different samples of oxide. He points out that if the oxides are allowed to heat, the sulphocyanic acid is likely to be decomposed; only a portion going to form ferrocyanide, and the remainder being changed into ammonium salts. In addition to this loss, the oxide that has heated is more difficult to treat; and consequently the cyanogen cannot be so readily extracted. Various plans were tried for separating the cyanogen, chiefly depending on the action first of water to dissolve the sulphocyanides, and then of alkalies to take up the ferrocyanides. But these were not entirely satisfactory; and a convenient and cheap method was discovered in which the spent oxide was treated with lime and sulphate of soda. One result of working this process was the discovery that a sulphocyanogen compound insoluble in water exists in the spent oxide, sometimes to the extent of upward of 2 per cent.

The latest contribution to this subject is a paper by Herr Leybold, of Frankfort-on-the-Main, which was read at a late meeting of the Bavarian Gas Association. This gentleman states that if an indifferent gas, such as hydrogen, is charged with vapor of ammonia by being led through an ammoniacal solution, and then passed over glowing coke, a considerable portion of the ammonia is decomposed into its elements, and at the same time formation of hydrocyanic acid takes place. With very hot coke and a slow stream of gas, more than half of the ammonia may be converted into hydrocyanic acid. So it is evident that the circumstances in the ordinary gas retort are favorable to the production of cyanogen, but too high a temperature decomposes it; and perhaps this is the reason why the proportion of cyanogen obtained in England is only a small fraction of the ammonia. Herr Leybold refers to an instance in which the proportion of ammonia to cyanogen was only 3 : 1; and it would be interesting to know the circumstances under which this was obtained, as the evidence above quoted shows it to be more like 8 : 1 or 10 : 1. At the outlet of the foul main, it appears the whole of the cyanogen has combined with ammonia. Some of it is deposited in the condensed liquor as sulphocyanide of ammonium. Very little is washed out in the scrubber, because carbonic acid has the effect of driving it forward. So the bulk goes on to the purifiers; and it is stated that oxide of iron has the property of absorbing it in the presence of carbonic acid. About 8 per cent. of the cyanogen is deposited in the condensers; rather less in the scrubbers; 50 to 70 per cent. in the purifiers; and the remainder passes on to the holders. The larger the number of purifiers, the greater the proportion of cyanogen absorbed; and it is stated that a purifier will be efficacious in this respect after it is saturated with sulphureted hydrogen. By passing the gas at a moderately rapid, but not excessive, speed through at least three boxes, one of which is allowed to remain in use for a long time, specially for cyanogen, the proportion of Prussian blue in the spent material can be raised as high as 10 per cent. It is said that the sulphide of iron is the active agent, and that hydrocyanic acid is not acted upon by clean oxide. If any is taken up by the moisture, it rapidly evaporates on exposure to air. Cyanide of iron is formed in the purifier, and becomes converted into Prussian blue on exposure to the atmosphere. This explains the fact that spent lime, though quite white on leaving the purifier, is apt to turn blue after free contact with the air. The product is not quite pure; and if ammonia is also present in the gas, a large proportion of sulphocyanide may be formed at the expense of the Prussian blue. This action also takes place if the ammonia is combined with an acid, though not to so great an extent as when it is free. Other alkalies have a similar effect, and also produce cyanides. An instance is given in which the improvement of the scrubbing plant, resulting in the recovery of one-third more ammonia, altered the proportions of Prussian blue and sulphocyanide from 3 and 5·96 per cent. respectively to 5·64 and 2·92 per cent. From this it appears that the modern methods of working are favorable to the recovery of cyanogen as Prussian blue in the oxide purifiers.

Cyanogen may also be recovered in the wet way by Herr Knublauch's patent process, which consists of scrubbing or washing the gas, just before the purifiers, with a mixture of caustic soda and green vitriol in solution. The iron precipitate is gradually dissolved, with the formation of ferrocyanide of soda. It is stated that the whole of the cyanogen can be recovered in this way, and that the saturated solution only requires to be concentrated by evaporation, when the cyanogen is obtained in a more valuable form than in the spent oxide. Assuming that a market could be found for the ferrocyanide solution, the simplicity of this process commends it to the attention of gas engineers. This process may also be used as a laboratory test for cyanogen. The crude gas is caused to pass through three Woulfe's bottles, charged with the solution. After passing a measured quantity, the solution is collected in a flask, boiled for fifteen minutes, filtered, and cyanogen precipitated as Prussian blue by the addition of a salt of iron. The precipitate is decomposed by caustic soda, and the clear solution is rendered acid with sulphuric acid, reduced by zinc, and titrated with permanganate in the usual way.

So far, it appears that there is a choice of methods by which the cyanogen present in coal gas can be recovered, either as Prussian blue or as solution of ferrocyanide of sodium or of potassium; and that these methods are not more complicated than those incidental to ordinary scrubbers, purifiers, and sulphate plant. But now we want to know whether buyers of spent oxide are inclined to take the proportion of Prussian blue that may be present as an item to be calculated in the price; and, if so, the market value per unit. We likewise wish to know if a market exists for alkaline ferrocyanides, and the price they will fetch; and also if the demand for cyanogen compounds is sufficiently extensive to take the whole of the production at gas works. Old shoes are said to be the chief source of these compounds at present; but the process of treatment is complicated and costly. Once assured of remunerative prices, there are plenty of gas engineers who would very shortly put a supply of cyanides on the market.—*Journal of Gas Lighting.*

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